This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

B 430430

TA
1
.A523

1916
UNIV. OF MICH.
LIBRARY

PROCEEDINGS OF THE

Twenty-Fifth Annual Convention

OF THE

American Railway
Bridge and Building Association

HELD AT

DETROIT, MICH.

October 19-21, 1915

REPORTS IN THIS ISSUE

- Locomotive Cranes
- Pile and Timber Trestles
- Railroad Water Tanks
- Small Coaling Stations
- Cost of Structures
- Efficiency
- Warnings for Overhead and Side Obstructions
- Reinforced Concrete Bridges
- Concrete Culvert Pipe and Concrete Piles
- Protection of Grade Crossings
- Manilla Rope
- Water Waste

INDEX ON PAGE THREE

PUBLISHED BY THE ASSOCIATION
C. A. Lichty, Secretary
319 NO. WALLER AVENUE
CHICAGO, ILL.

EQUITABLE BUILDING, New York
Graham-Burnham & Co., Architects
Thompson-Starrett Co., Builders
Steel, granite and cement protected from rust, electrolysis, disintegration and discoloration by "R. I. W." Preservative Paints and Compounds.

Steel Need Not Rust!
Wood Need Not Rot!
Nor Concrete "Dust"!

MILLIONS invested in house-walls, bridge-spans, cement floors and other structures, are needlessly wasted every year through the ravages of time and the elements.

R.I.W.
REMEMBER IT'S WATERPROOF
PRESERVATIVE
PAINTS AND COMPOUNDS

will element-proof and preserve any structure. There are "R.I.W." *specifics* for every conceivable purpose—preventing corrosion, electrolysis, disintegration and discoloration. Write for "R.I.W." literature.

TOCH BROTHERS
Established 1848
Inventors and Manufacturers of Preservative Paints, Enamels and Varnishes
320 Fifth Avenue, New York
Works: Long Island City, N. Y., London, England, and Toronto, Ont., Canada

GEO. W. REAR
President, 1915-1916

PROCEEDINGS OF THE

Twenty-Fifth Annual Convention

OF THE

American Railway
Bridge and Building Association

Successor to the

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF
BRIDGES AND BUILDINGS

HELD AT

DETROIT, MICH.

OCTOBER 19-21, 1915

Official Badge

PRICE, ONE DOLLAR

BRETHREN PUBLISHING HOUSE
ELGIN, ILLINOIS
1915

PAST PRESIDENTS IN ATTENDANCE AT DETROIT CONVENTION, OCT. 20, 1915.

From left to right.—R. H. Reid, A. S. Markley, J. N. Penwell, W. A. McGonagle, (S. F. Patterson, Secretary Emeritus,) A. E. Killam, L. D. Hadwen, F. E. Schall, J. P. Canty, J. B. Sheldon, H. Rettinghouse, C. A. Lichty.

TABLE OF CONTENTS

REPORTS IN THIS ISSUE.

Locomotive Cranes, ... 47
Pile and Timber Trestles, ... 71
Railroad Water Tanks, ... 129
Small Coaling Stations, ... 177
Cost of Structures, ... 181
Efficiency, ... 07
Warnings for Overhead and Side Obstructions, ... 215
Reinforced Concrete Bridges, ... 221
Concrete Culvert Pipe and Concrete Piles, ... 253
Protection of Grade Crossings, ... 315
Manilla Rope, ... 23
Water Waste, ... 343

Officers for 1915-16, ... 4
Past Presidents, ... 5
Committees for Current Year, ... 6
Opening Exercises, ... 9
President's Address, ... 16
Members Present at Last Convention, ... 20
Report of Membership Committee, ... 21
Report of Executive Committee, ... 23
Report of Secretary, ... 24
Report of Treasurer, ... 25
Report of Committee on Relief, ... 25
Report of Obituary Committee, ... 26
Report of Committee on Nominations, ... 27
Report of Committee on Subjects, ... 31
Report of Committee on Resolutions, ... 35
Memoirs, ... 36
List of Annual Conventions and Attendance, ... 353
List of Officers from Organization, ... 354
Constitution and By-Laws, ... 356
Directory of Members, ... 361
Mileage of Railways Represented with Names of Members, ... 374
Index to Advertisements, ... 388

OFFICERS FOR 1915-16

G. W. REAR, ...President
Southern Pacific Co., San Francisco, Cal.

C. E. SMITH, ...First Vice-President
Missouri Pacific Ry., St. Louis, Mo.

E. B. ASHBY, ...Second Vice-President
Lehigh Valley R. R., New York City.

S. C. TANNER, ...Third Vice-President
Baltimore & Ohio R. R., Baltimore, Md.

LEE JUTTON, ...Fourth Vice-President
Chicago & Northwestern Ry., Madison, Wis.

C. A. LICHTY, ...Secretary-Treasurer
Chicago & Northwestern Ry., Chicago, Ill.

S. F. PATTERSON, Secretary Emeritus, ...Concord, N. H.

THE EXECUTIVE COMMITTEE

Consists of the Officers and the Following Members:

F. E. WEISE, Chicago, Milwaukee & St. Paul Ry., ...Chicago, Ill.
W. F. STROUSE, Baltimore & Ohio R. R., ...Baltimore, Md.
C. R. KNOWLES, Illinois Central R. R., ...Chicago, Ill.
ARTHUR RIDGWAY, Denver & Rio Grande R. R, ...Denver, Colo.
J. S. ROBINSON, Chicago & Northwestern Ry. ... .Chicago, Ill.
J. P. WOOD, Pere Marquette Railroad, ...Saginaw, Mich.

PAST PRESIDENTS

1891-92	*O. J. Travis,	Pinehurst, Wash.
1892-93	*H. M. Hall,	Ohio & Mississippi Ry., Olney, Ill.
1893-94	*J. E. Wallace,	Wabash R. R., Springfield, Ill.
1894-95	G. W. Andrews,	Baltimore, Md.
1895-96	W. A. McGonagle,	D. M. & N. Ry., Duluth, Minn.
1896-97	James Stannard,	Kansas City, Mo.
1897-98	*Walter G. Berg,	Lehigh Valley R. R., New York City
1898-99	J. H. Cummin,	Bay Shore, N. Y.
1899-00	A. S. Markley,	Chicago & Eastern Illinois R. R., Danville, Ill.
1900-01	W. A. Rogers,	37 W. Van Buren St., Chicago, Ill.
1901-02	W. S. Danes,	Wabash R. R., Peru, Ind.
1902-03	B. F. Pickering,	Boston & Maine R. R., Salem, Mass.
1903-04	A. Montzheimer,	Elgin, Joliet & Eastern Ry., Joliet, Ill
1904-05	C. A. Lichty,	Chicago & Northwestern Ry., Chicago, Ill.
1905-06	J. B. Sheldon,	N. Y. N. H. & H. R. R., Providence, R. I.
1906-07	J. H. Markley,	Toledo, Peoria & Western Ry., Peoria, Ill.
1907-08	R. H. Reid,	L. S. & M. S. Ry., Cleveland, O.
1908-09	J. P. Canty,	Boston & Maine R. R., Fitchburg, Mass.
1909-10	J. S. Lemond,	Southern Ry., Charlotte, N. C.
1910-11	H. Rettinghouse,	C. St. P. M. & O. Ry., St. Paul, Minn.
1911-12	F. E. Schall,	Lehigh Valley R. R., So. Bethlehem, Pa.
1912-13	A. E. Killam,	Moncton, N. B.
1913-14	J. N. Penwell,	L. E. & W. R. R., Tipton, Ind.
1914-15	L. D. Hadwen,	C. M. & St. P. Ry., Chicago, Ill.

*Deceased.

SUBJECTS AND COMMITTEE APPOINTMENTS FOR 1916

1. Water Supply. (a) Intakes and Intake Lines.

(b) Internal Combustion Engines.

C. R. Knowles, Chairman, I. C. R. R., Chicago.
C. A. Lichty, C. & N. W. Ry., Chicago.
James Dupree, C. T. H. & S. E. Ry., Crete, Ill.
J. J. Murphy, Sou. Pac. Co., Oakland, Cal.

2. Floors for Shops, Etc.

D. Rounseville, Chairman, C. & N. W. Ry., Chicago.
J. S. Robinson, C. & N. W. Ry., Chicago.
G. A. Mitchell, G. T. Ry., Toronto, Ont.
R. M. Bowman, L. E. & W. R. R., Indianapolis, Ind.
G. E. Boyd, D. L. & W. R. R., Buffalo, N. Y.

3. Paint and Its Application to Railway Structures.

C. E. Smith, Chairman, Mo. Pac. Ry., St. Louis, Mo.
F. E. Schall, L. V. R. R., So. Bethlehem, Pa.
C. W. Wright, L. I. R. R., Jamaica, N. Y.
H. B. Stuart, G. T. Ry., Montreal, Que.
Chas. Ettinger, I. C. R. R., Chicago.

4. Caring for and Handling Creosoted Material.

E. T. Howson, Chairman, Ry. Age Gazette, Chicago.
F. D. Mattos, Sou. Pac. Co., Oakland, Cal.
D. A. Shope, A. T. & S. F. Ry., Fresno, Cal.
J. S. Lemond, Southern Ry., Charlotte, N. C.

5. Blank Forms for B. & B. Dept. Use.

R. C. Sattley, Chairman, C. R. I. & P. Ry., Chicago.
G. W. Hand, C. & N. W. Ry., Chicago.
B. F. Ferris, Sou. Pac. Co., Los Angeles, Cal.
G. A. Rodman, N. Y. N. H. & H. R. R., New Haven, Conn.

6. Modern Methods of Driving Piles.

Maro Johnson, Chairman, I. C. R. R., Chicago.
J. P. Canty, B. & M. R. R., Fitchburg, Mass.
R. H. Reid, N. Y. C. R. R., Cleveland, O.
J. P. Wood, P. M. R. R., Saginaw, Mich.
O. F. Dalstrom, C. & N. W. Ry., Chicago.

7. Fireproofing Roofs of Wooden Buildings.

J. N. Penwell, Chairman, L. E. & W. R. R., Tipton, Ind.
Niles Searls, Sou. Pac. Co., San Francisco, Cal.
E. C. Morrison, Sou. Pac. Co., San Francisco, Cal.
J. W. Miller, C. & N. W. Ry., Chicago.
F. O. Draper, I. C. R. R., Chicago.

8. Efficient Methods of Handling Work and Men.

F. E. Weise, Chairman, C. M. & St. P. Ry., Chicago.
E. R. Wenner, L. V. R. R., Ashley, Pa.
S. C. Tanner, B. & O. R. R., Baltimore, Md.
J. F. Pinson, C. M. & St. P. Ry., Seattle, Wash.

9. Station Buildings for Passenger Service Only.

M. A. Long, Chairman, B. & O. R. R., Baltimore, Md.
E. B. Ashby, L. V. R. R., New York City.
G. W. Andrews, B. & O. R. R., Baltimore, Md.
J. B. Gaut, G. T. Ry., Chicago.

10. Economical Handling of Concrete on Smaller Jobs.

L. D. Hadwen, Chairman, C. M. & St. P. Ry., Chicago.
J. W. Wood, A. T. & S. F. Ry., Needles, Cal.
C. F. Green, Sou. Pac. Co., Sacramento, Cal.
G. H. Stewart, B. R. & P. Ry., E. Salamanca, N. Y.

11. Small Coaling Stations.

Lee Jutton, Chairman, C. & N. W. Ry., Madison, Wis.
W. F. Strouse, B. & O. R. R., Baltimore, Md.
J. H. Nuelle, N. Y. O. & W. R. R., Middletown, N. Y.
G. W. Kinney, D. & R. G. R. R., Salt Lake City, Utah.

NOMINATIONS.

R. H. Reid, Chairman, N. Y. C. R. R., Cleveland, O.
S. F. Patterson, 35 Pleasant St., Concord, N. H.
J. N. Penwell, L. E. & W. R. R., Tipton, Ind.
J. P. Canty, B. & M. R. R., Fitchburg, Mass.
F. E. Schall, L. V. R. R., So. Bethlehem, Pa.

SUBJECTS.

F. E. Weise, Chairman, C. M. & St. P. Ry., Chicago.
J. B. Sheldon, N. Y. N. H. & H. R. R., Providence, R. I.
J. M. Staten, C. & O. Ry., Richmond, Va.

RELIEF.

A. Montzheimer, E. J. & E. Ry., Joliet, Ill.

MEMBERSHIP.

H. A. Horning, Chairman, M. C. R. R., Jackson, Mich.
G. A. Rodman, N. Y. N. H. & H. R. R., New Haven, Conn
B. F. Gehr, P. C. C. & St. L. Ry., Richmond, Ind.
W. S. Corbin, Sou. Pac. Co., San Pedro, Cal.
J. P. Yates, N. O. T. & M. R. R., DeQuincy, La.

PUBLICATIONS.

J. S. Robinson, Chairman, C. & N. W. Ry., Chicago.
E. S. Meloy, C. M. & St. P. Ry., Chicago.
R. S. Sattley, C. R. I. & P. Ry., Chicago.

ARRANGEMENTS.

C. R. Knowles, Chairman, I. C. R. R., Chicago.
E. L. Loftin, Q. & C. Ry., Vicksburg, Miss.
F. W. Bailey, G. H. & H. R. R., Galveston, Tex.
M. A. Smith, I. C. R. R., New Orleans, La.

OBITUARY.

B. F. Pickering, B. & M. R. R., Salem, Mass.

Proceedings of the Twenty-fifth Annual Convention
of the

American Railway Bridge and Building Association

Held in the Hotel Statler

Detroit, Mich., October 19, 21, 1915

MORNING SESSION.

Tuesday, Oct. 19, 1915.

The twenty-fifth annual convention was called to order at 10 A. M., by President L. D. Hadwen.

Prayer was offered by J. N. Penwell.

The President:—It is very fitting that we should be welcomed to this fine city by its chief executive. It gives me great pleasure to introduce to you the mayor of Detroit, the Hon. Oscar B. Marx.

The Mayor:—Mr. President, ladies and gentlemen of the American Railway Bridge and Building Association: In behalf of the people of the city of Detroit I desire to extend to you a most hearty welcome. I am glad, gentlemen, to see that you brought your chaperons along. No convention is a success unless you have the ladies with you, because they always make things pleasant for all of you.

I am very glad, indeed, that you came here at this time, because we may ask for your assistance. Last year we had the misfortune to have our bridge connecting the mainland with our beautiful park, Belle Isle, burn down. I do not know and I do not think the people know exactly what they want in the way of a new bridge. If you gentleman can make any suggestions to us on this subject, you can rest assured that we will be a pleased public.

We are very glad to have you visit our city, and we trust that, in going about, you will have an opportunity to see some of our beautiful parks, our wide and clean streets and our wonderful automobile factories. You have an opportunity; don't fail to visit these factories. To see an automobile coming out every two minutes complete is a wonderful thing. Take the time to go out to the Ford factory, where between 16,000 and 18,000 people are employed, and see how quickly they turn out these machines.

I am sorry that I can not stay with you very long this morning, as I have another convention to address, a Safety First meeting. We are very glad that you have selected our city and we want you to feel that when you leave here, you have had such a good time that you will want to come back to Detroit. I hope your business meetings will be successful and beneficial to every one of you. It is in exchange of views of this kind that people learn, and gatherings of this kind can only do good. As I said, I appreciate having had the honor of addressing you this morning and I thank you for being with us. I have no key to the city to hand you, because we have so many conventions here that I had to throw the key into the river, but the city is yours. Thank you. (Applause.)

The President:—I am going to call on our vice-president, Mr. Rear, to thank the mayor for his address.

Mr. Rear:—Mr. Mayor, in behalf of the association I take great pleasure in thanking you for your cordial welcome to this city. I must say that I am under a little handicap. We held the convention in Los Angeles last year. One of the members present at that time, who we afterwards found was from Michigan, kept saying, "Let's go to Detroit next year," and everybody around would say, "Yes, let's go." I said to myself, "Where is Detroit?" It seems to me that I have heard of the place, but I couldn't locate it at all. About a month later I was again in Los Angeles and like a fool I attempted to cross Spring Street, in the middle of the block. Pretty soon they were tooting all around me, and said, "That's where they come from,—Detroit."

We feel that we are indeed welcome in this town. It is a wonderful city. We feel that we will have a good time here and will go away wanting to come back again. We have been welcomed in many cities, but there is none where we have been more heartily welcomed nor where we expect to have a better time or could have a better time. We will take what opportunity we have to visit these factories, as we have an invitation from them.

In regard to our advising you concerning the replacement of the bridge this is probably one subject about which we would hesitate to offer any advice, as you have already probably had enough.

You congratulate us on bringing the ladies with us. We don't just know whether that is the right thing or not. We started it once and now the trouble is that if a man's wife can't come, he can't come. (Laughter.) Again, on behalf of this association, I thank you for your very cordial welcome to this city. (Applause.)

The President:—As a railway organization, it seems proper that we should have a word from the railroads centering in Detroit, and we have with us today Mr. J. C. Bills, general solicitor for the Pere Marquette. He will give us a few words from the railroad standpoint.

Mr. Bills:—Mr. Chairman, ladies and gentlemen: I was a little surprised that when your committee picked a member of the railroad organizations in Detroit to welcome you here they should select a lawyer. I have always been under the impression that most of the railroad organizations regard the lawyers as a nuisance.

That reminds me of the story that I heard once of a railroad president who got into a dispute with a man who was threatening to sue his company and the man said, " I will sue you in the justice court." The president said, " All right, we will be there." The man said, " If I don't get satisfaction there, I will appeal to the circuit court." The president said, " All right, we will be there." The man said, " If I still fail there, I will appeal to the Supreme Court." The president said, " All right, we will be there." Then the man said, " To win this case against you, I'd carry it right down into the place of eternal fire " ; and the president said, " All right, my lawyers will be there." (Laughter.)

However, the railroad fraternity of Detroit is sensible indeed of the honor that has been conferred on it by having this convention meet here again. When you met here in 1899, 16 years ago, you were told that Detroit was a beautiful city. That is still true, and now we can add that it is an exceedingly busy city, for, from Lake Erie to Lake St. Clair, there is an almost unbroken line of industries representing the constructive industries of the country. You will also find that Detroit is a friendly city, and particularly friendly to its railroads. We have had considerable experience here in that line and it has been a source of great gratification to us that, in the recent controversies and struggles that the railroads have had in an effort to get compensatory rates to meet the rising cost of operation, the principal industries of Detroit, as represented by their Board of Commerce, has stood with us and not against us, both before the Interstate Commerce Commission and before the Michigan Railroad Commission. This naturally engenders in us an exceedingly friendly feeling toward the city, and that feeling I am sure you will encounter and share.

I am very glad to have also brought to the attention of the citizens of Detroit one of the great constructive departments of railroad work. The trouble has been lately that whenever the railroads have been before the public it has been in connection with some financial transaction or some matter of auditing or in connection with the alleged breach of some law, and the public is likely to get the idea that the railroad business is composed of financiers, sleight of hand accountants and talkative lawyers, so I am exceedingly glad to have you here on that account. I think that the real work of railroading has been much obscured in the last few years by these controversies in which the railroads have been involved, and to obscure the work of the railroads in this country is to obscure three quarters of a century of magnificent achievement.

The other night I was reading a short history of a trip Geo. Washington took on horseback into the West about 1783 or 1784. At that time he said that in his judgment it would be a thousand years before the country was settled as far west as the Mississippi river, and that he doubted seriously whether the country was not unwise in having such wide boundaries, because, with the various kinds of climate and classes of people, it seemed impossible to him that the country could have a unity that would hold it together. Now, of course, the thing that he could not foresee and that nobody could foresee at that time was the enormous fact of the application of steam to the problem of transportation. He could not see that there would arise in the country a force that would bind the country together, a force that would make the distance from New York to Chicago shorter than it was in his day from New York to Philadelphia.

Some day when the history of the United States is written, the proper credit will be given to the transportation interests of the country and particularly to the men who have spent their lives in this great force in our social and economic life. There is no more useful business than that of transportation. Whether a man is engaged in suburban transportation which relieves the congested situation in the great cities, or engaged in the longer distance transportation that brings the producer and consumer together, or in the swift movement of troops in defence of his country in time of war, he is engaged in a highly useful, valuable and uplifting occupation. I have had occasion to say something of that kind to various people in public life in the past, and particularly to the members of the legislature, and the usual reply that I get is that they had not thought of it in that way,—that it had not been brought to their attention. Their attitude in that way reminds me of a story I heard sometime ago of something that happened on a railroad. It seems that they had a little collision out on the line and in the morning the superintendent got a long telegram from the conductor which went into great detail as to the number of cars involved, the exact place of the collision, the amount of track torn up, the interval before the main line would be clear, etc., but nothing was said of the cause of the collision and nothing about the engineer. So he wired the conductor and said, "Please let me have at once the engineer's version of this accident." The conductor wired back, "The engineer was in no way involved in this accident as he was asleep in his cab at the time." (Laughter.) That is the general situation in regard to a good many public officials and the railroads.

I am very glad that you have concluded to escape for a little while from the details of your work to see how the other fellow does things and to look at the larger and more generous features of your profession. The railroad fraternity in Detroit is very glad to see you, and we hope that the next time you won't wait 16 years before you come back to see us again. (Applause.)

The President:—We have with us, as an old member of our association, a railroad president, Mr. McGonagle. I wonder if he will give us a few remarks in response to Mr. Bills' address.

Mr. McGonagle:—Mr. Bills, Mr. President, ladies and gentlemen: I think the welcome given us today is a genuine one. I did not have the pleasure of being in Detroit when the association met here the last time, but I had full reports from friends of mine and I know you had a good time. I know we are going to have a good time here today when we have the old members present, including myself as the oldest, and the ladies. It is always a pleasure for us to see them at our conventions. We are prepared to listen to the wise counsel of these members who have prepared committee reports and we are also prepared to see the wonderful industries of this city. I know the railroad men of Detroit mean the welcome they have extended to us, and I know from their prosperity that the words spoken by Mr. Bills as to the treatment of the railroads by the public in Detroit are true. I sincerely trust that, throughout this great country of ours, the pattern set by the people of Detroit will be followed, and I know that all the people of this country will benefit by that kind of treatment.

As I look back over the last quarter of a century, when we first met at St. Louis, it seems but a short time, although during that period many of our oldest members have passed over the bridge of life into the beyond. Those members were responsible for the success of our association: broad-gage men, men of long years of experience, they brought to this association the elements of personal friendship. The success of all industry today, the success of government and the success of the people is based on this broad principle of personal friendship. As we go along, year after year, this idea seems to come to the front. It is no longer a case of oppression of the people, it is no longer the problem to see what we can put over the people, but to find out what the people want, and then try to give it to them, not in a halting way, but in a generous way, letting them understand that the transportation lines of this country are working in harmony with the people to bring about the best good for all. I certainly trust, as we work together in the years that are to come, that this idea of personal friendship will continue, and I know that, based on this idea, we will rise to heights that we hardly dream of at the present time and that our association will draw to its numbers men of experience, men of knowledge and men of action as it has in the past, and that our association will stand in the foremost ranks of railway associations, working together, not only for the betterment of the people but for the betterment of ourselves.

Our association has a foundation stone of character. It was shown in Chicago at our meeting there when liquor was banished from the association rooms. This is the class of men that work developed so many years ago. The opening of the exercises of our association with prayer means a great deal. It means that there is a true Christian character behind this association that has impelled it onward and upward, and I know that with these foundation stones we will build higher and higher and a nobler existence for our association in the future. Mr. President, I thank you for the opportunity of being present here today. I think it was your letter urging me to come, that caused me to throw aside business matters for the time and come back and meet with old and true friends. I have already enjoyed the association of the older members and I sincerely trust that the new members will give me the pleasure of meeting them and trying to know them as I knew the older members in the time of O. J. Travis, J. H. Cummin, Walter G. Berg, Aaron Markley, "Deacon" Patterson, our old friend "Johnny Bull" and many others whom I can hardly enumerate at this time. It is a period of real rest for me to come back into the spirit of this association and I thank you for this privilege of saying a few words while the ladies are present, because it is they, after all, who are the foundation for the success of our association. They make us come to these meetings. I know that in the years that are to come they will come in greater numbers and we will have to come along. Thank you. (Applause.)

The President:—We have heard from Member No. 1 and it seems only fitting that I should ask our secretary to read one or two letters that have been received from some of our oldest and most esteemed members. Amongst these there is one from a man who stands high in the engineering world who is an example to all the younger men, and one whom those who have had the privilege of working under deem it the greatest privilege that has come to them in a special way. I am going to ask the secretary to read a letter received from Mr. Onward Bates, past president of the American Society of Civil Engineers, also a letter from Mr. Cummin, whom Mr. McGonagle mentioned.

Chicago, Ill., October 15, 1915.

Mr. L. D. Hadwen;

Our secretary has advised me that my dues for the current year are paid, and I can, therefore, write this with clean hands. I am very sorry that I must decline your invitation to make some remarks at the Detroit convention, especially as it was made to me on the ground that I am a "has been," and could be exhibited at the convention without any reflection on the active members who at present have charge of this useful and important department of railway service. If I could encourage them or do them any good it would be a sufficient reason for my accepting your invitation; but I think I would be more inclined to accept it for the gratification it would be to me to meet such a body of men, and to renew some of my old and valued acquaintances.

If you can find time during the burst of oratory, which you will deliver as a retiring president, to give my greetings to those present, I will appreciate it. I hold in the highest esteem the Association of Railway Superintendents of Bridges and Buildings and its successor.

I find that I am not a charter member. Your list of members shows that I am No. 24, while our honored president is No. 203. It is gratifying to observe that the last number on the list is No. 569. This indicates satisfactory growth, and the proceedings of the association show what it has accomplished in the bridge and building departments of our railways. It has not only kept up with the times, but has constantly improved them, and though some of its old members have depreciated until we are only fit for the scrap heap, the association has constantly grown in strength and vigor.

I am qualified to make these remarks for the reason that for many years I have not had any active part in association work, which I have observed with the cool judgment of an interested bystander. I have great respect for the personnel of the association. Only an upright man is qualified to be a superintendent of bridges and buildings. Such men carry great responsibilities, and the records show that they have met these with zeal and faithfulness, and in so doing have set the best examples of good citizenship.

I present my compliments and good wishes to the convention.

Yours truly,

Onward Bates.

Brightwaters, L. I., Oct. 2, 1915.

Mr. L. D. Hadwen;

I have delayed answering your letter in the hope that I might be able to give a favorable reply, but I am sorry to say that I will not be able to be with you at the convention. No one can regret it more than I, for several reasons. The last time we met at Detroit I had the honor of being president, and I would very much like to see the immense changes made on account of the automobile industry. Then also this will be the twenty-fifth meeting, and I regret missing that. And lastly, I would be more than pleased to meet once more the many strong friends, that I met in the old days. But frankly, I can not afford to make the trip at this time. Business has been very dull for a long time, and does not look any brighter at present. I have just returned from Washington, D. C., where I attended the G. A. R. encampment as it will probably be the last big parade I shall take part in. I met "Deacon" Patterson there and had a pleasant time with him. Hoping that you will have a most successful meeting and with kindest wishes to all the "Boys," I am,

Yours most sincerely,

J. H. Cummin.

Letters were also received from J. H. Markley, J. T. Carpenter, Floyd Ingram, J. O. Thorn, Frank Ingalls, G. A. Mountain, B. F. Pickering, Geo. W. Andrews, C. P. Austin, W. M. Noon, James Stannard, F. W. Tanner, J. M. Staten, A. Montzheimer, and many others who stated that they would be unable to be present.

The President:—It is rather unfortunate perhaps that the order of procedure places the burden on the president of having to deliver his address after the eloquence of much worthier men has reached your ears.

PRESIDENT'S ADDRESS.

Custom provides that at the close of his year of office, your president address you and that this be done at the opening of the annual convention. As, doubtless, many of my predecessors have experienced before me, this requirement was lightly thought of when taking office, but as the days of the convention drew near, I realized that though in other matters of the association my function was mainly to make some one else work, here was a task which I could not delegate and that even though I might get our worthy secretary to write an address for me, I would be expected to deliver it. It is the bridgeman's business to provide crossings and restore traffic when communications are broken as quickly as possible with the available material, and I will, therefore, try and give my remarks brevity so that you will be carried over quickly to the next item on our program.

At this, our twenty-fifth convention, we rejoice to have with us several of our charter members and so many of our former presidents to whose zealous care and wise guidance our association owes so much. Those of you who were present at the historic meeting in St. Louis in 1891, when the Association of Railway Superintendents of Bridges and Buildings was founded, have in the growth that has resulted the best demonstration of your presence in assisting at its foundation. While our name has been shortened, our membership roll has increased tenfold, so that we now have a roll call well on to six hundred.

The twenty-five years that cover the life period of our association have been fruitful in great changes, both as to materials and methods employed in railway bridge and building work, and I am in hopes that before the convention is over, we shall have an opportunity of hearing some of the deans of our calling review the progress made. When our first meeting was held in St. Louis in 1891, there were few superintendents of bridges who were called on to provide for engine loadings that would classify above Coopers E-35, while now structures must be designed for Coopers E-55 loading or higher and the demands made by the constantly increasing weight of locomotives and cars have resulted in the changing out of many structures that in the association's youth seemed ample to care for many years' development.

Our association witnessed in its first years the substitution of steel for wrought iron in girder spans and trusses and now sees the employment of nickel steel and other special steels in such large trusses as are under erection at New York, Quebec, Metropolis and Memphis. The wooden Howe truss which was to be found on main lines all through the West, and which had so important a place in our early proceedings, has been driven almost out of the field and open floor pile bridges seem destined to follow in its wake, as far as main lines are concerned.

In the field of masonry, the changes have been equally striking. The employment of concrete with its ready adaptability has largely displaced the stone and rubble masonry that prevailed in the early nineties and with its freedom from the need of skilled labor. Its adaptability to mechanical handling has made possible the immense masonry railroad structures, such as the Tunkhannock viaduct, which labor costs would, otherwise, have rendered prohibitive. Not content with its dominance in substructure work, the further development of concrete as reinforced concrete has invaded fields formerly held by structural steel and other building materials and the past decade has provided many instances where this material has enabled all masonry structures to be substituted for composite types as, for instance, where steel girders have been taken out and concrete slabs put in their place. The use of reinforced concrete has done much to develop solid floor construction, permitting of bridges with continuous ballast across the structures; though this end has also been attained by employing creosoted timber decks.

With the changes in materials and design have been corresponding developments in the methods of handling and equipment employed. Derrick cars and locomotive cranes with capacities up to 100 tons are now employed for erection purposes, while hand-operated crabs and gallows frames were the erection tools available when our proceedings were first issued. All the mechanical appliances for mixing and placing concrete have been developed in the last decade.

Probably nothing has been so fruitful in work for bridge and building men as the various grade separation projects that have had their inception since the founding of our association. While track elevation and depression have become household words with many of us, the growth of our cities will make this an ever increasing field of employment. As a notable illustration of grade separation work and an example of the magnitude of such projects, we are to see here in Detroit what has been done by the Michigan Central.

In railway building work, the most spectacular accomplishments are the splendid terminals that have been erected within the past 20 years at our important centers, oftentimes in conjunction with grade separation projects as in Detroit, but much attention has also been given to the improvement of the smaller stations and buildings. Mechanical coaling stations are among the interesting facilities that have come into existence during our association's life.

A study of our past proceedings forms an interesting chronicle of bridge and building practice and calls for us to make our discussions as representative as possible and also for a widespread personnel of our committees to insure the expression of broad views, and to avoid treating the subjects from a local or individual aspect.

To me the success of our association lies in the fact that it brings together and provides for a free expression of views between all those who go to make up a bridge and building organization and that its constitution is broad enough to admit the man in actual charge of work in the field no less than the engineer who designs the work to be executed. No matter whether departmental or divisional methods of organization are employed, there is a tendency for separation into two classes, namely: field men and office men. Efficiency can not be secured unless there is full coöperation between these two and I believe that the American Railway Bridge and Building Association is the best possible agency for promoting this harmony.

With 25 years to look back upon we may consider ourselves a well established organization, but growth is essential to vigorous life and as the number of men in various bridge and building activities increases, we should see that representative members are added to our ranks so that our association may prosper continually. During the past year, thanks to our able membership committee, we have had applications from 97 candidates eligible for membership, so that our growth is being well maintained.

It is with sorrow that I have to chronicle the death, during the past year, of members who have meant much to the association and whose friendly counsel we shall all miss. Owen J. Travis, the prime mover in founding the association, whom it would have been our delight to honor at this anniversary, died Nov. 8th. Grosvenor Aldrich, who we hoped, during the coming year, would occupy the presidency of the association in which he has taken such steadfast interest, passed away in July. We may profitably contemplate the records of these men as examples of devoted membership.

We are gathered today in convention in this city after an absence of 16 years, and from the accounts of those who, like our worthy secretary, experienced its hospitality then, we know that we shall be well taken care of and demonstrate that this is the city "where life is worth living." Since we last met here Detroit has become the center of a vast industry and in becoming acquainted with some of the wonders of automobile manufacture, I am sure we shall find much of educational value to us in our own work.

With its many severe storms and with the business depression that has prevailed, the year has been a strenuous one for all bridge men, called as they were to meet emergencies with a much reduced force. Nevertheless, our committees have been so assiduous in their work that we have ten reports available in advance and can look forward to profitable sessions as a result of their efforts. I want to urge all members, new as well as old, to show their appreciation of the committees' work by studying these advance reports carefully before they come up for discussion and to participate where they have information to offer or views to express bearing on the subject. Let us remember that we are here united for a common purpose,—the improvement of our work and increased economy for the transportation systems we serve and we can here find a common ground of mutual esteem, no matter how our opinions may differ.

While the volume of work has been below that in more prosperous seasons, we have just as severe tasks in the rigorous economies required by adverse conditions. The bountiful harvests this year together with awakening public sentiment towards the railroads' reasonable needs surely give promise that we may now hope for rapid improvement and consequent increase of our forces. We should, therefore, so organize that when the rush of work comes, it may find us prepared and ready to expand; each one educating and training his subordinates to fill the positions ahead of them and to broaden himself for increased responsibilities. It is here that we should benefit by our membership and will gain in proportion to our efforts in committee and convention.

Let me take this opportunity of asking that there be a close attendance of the members at our sessions and that they be in their seats punctually at the time set. We have three full days before us and by strict attention during our business sessions, we will with a better grace enjoy the entertainment provided for us.

It is a good augury for the success of this convention that so many of you are accompanied by your families; and I would like to enlist the ladies' help in securing punctual attendance on the part of the members at the sessions. These conventions are to many their one opportunity throughout the year of enjoying an excursion with their wives and it is to the ladies in attendance that we are indebted for the social success of our annual meetings. The new members should see that they learn quickly to follow this custom and bring their wives with them to the next convention.

Finally, at the close of my term I wish to thank all the officers and committees for their hard work and loyal support during the past year and especially for the faithful service of our secretary, the volume of whose labors only those in close touch with our affairs can appreciate. The efforts made by old members to be present this year is a fine tribute to the association and makes me more than ever appreciate the honor you have conferred on me as your president during the past year.

The President:—Before we go on with our regular business sessions, we will have a recess so that the ladies can start out to see the sights and enjoy the entertainment which we understand is to be provided for them.

After the secretary made some announcements, he requested "Deacon" Patterson to come forward so that the new members might see him, which he did and was received with applause. A short recess was then taken for the payment of dues, etc.

The president appointed F. E. Weise assistant secretary.

Roll call was dispensed with and the names of those present were secured by the card registration system. According to the registration the following members were in attendance:

P. Aagaard,
W. E. Alexander,
E. E. Allard,
T. O. Andrews,
S. D. Bailey,
F. C. Baluss,
E. K. Barrett,
A. H. Beard,
J. D. Black,
S. C. Bowers,
R. M. Bowman,
Z. T. Brantner,
J. B. Browne,
W. H. Burgess,
J. M. Caldwell,
W. M. Camp,
J. P. Canty,
W. M. Cardwell,
F. M. Case,
W. W. Casey,
W. Cayley,
W. A. Clark,
J. E. Cole,
F. J. Conn,
W. S. Danes,
I. A. Draper,
Jas. Dupree,
W. O. Eggleston,
C. H. Fake,
B. F. Ferris,
J. W. Fletcher,
C. F. Flint,
J. B. Gaut,
B. F. Gehr,
F. N. Graham,
J. Gratto,
F. M. Griffith,
Edw. Guild,
L. D. Hadwen,
Thos. Hall,
G. E. Hanks,
J. Henderson,
R. C. Henderson,
P. Hofecker,
H. A. Horning,
E. T. Howson,
B. M. Hudson,
J. Hunciker,
Lee Jutton,
A. E. Killam,
A. H. King,
F. E. King,
C. R. Knowles,
G. W. Land,
P. P. Lawrence,
C. A. Lichty,
E. L. Loftin,
Geo. Loughnane,
G. Manthey,
A. S. Markley,
W. A. McGonagle,
N. McLean,
J. McMahon,
A. McNab,
A. B. McVay,
E. S. Meloy,
W. F. Meyers,
G. A. Mitchell,
J. D. Moen,
D. G. Musser,
P. N. Nelson,
P. J. O'Neill,
Jas. Parks,
S. F. Patterson,
J. N. Penwell,
F. M. Pickering,
I. O. Potts,
W. F. Rankin,
G. W. Rear,
R. H. Reid,
J. S. Replogle,
H. Rettinghouse,
M. Riney,
Jno. Robinson,
J. S. Robinson,
G. A. Rodman,
W. A. Rogers,
D. Rounseville,
G. T. Sampson,
R. C. Sattley,
F. E. Shall,
Chas. Scott,
F. E. Shanklin,
J. B. Sheldon,
F. P. Sisson,
E. U. Smith,
J. L. Soisson,
G. H. Stewart,
E. G. Storck,
H. B. Stuart,
H. C. Swartz,
Wm. Sweeney,
S. C. Tanner,
D. B. Taylor,
C. Thompson,
W. Tichbourne,
J. E. Toohey,
E. E. R. Tratman,
E. J. Vincent,
I. Q. Walker,
C. F. Warcup,
F. E. Weise,
A. Weldon,
G. W. Welker,
E. R. Wenner,
J. L. Winter,
J. P. Wood,
W. E. Wood,
C. W. Wright,
G. A. Wright,
D. C. Zook.

The following applicants for membership, subsequently elected, were also present:

N. N. Barber,
C. L. Beeler,
G. W. Black,
J. G. Bock,
Thos. Brown,
J. E. Buckley,
J. P. Copp,
L. A. Cowsert,
W. E. Duckett,
E. W. Fair,
Franklin Gable,
W. J. Galloway,
E. F. Gardner,
Chas. Gradt,
A. W. Harlow,
F. J. Hodges,
J. S. Huntoon,
R. E. James,
C. H. Johnson,
Andrew Leslie,
E. R. Lewis,
Chas. Mines,
Homer Morgan,
W. H. Mulcahy,
A. B. Nies,
J. A. Owen,
R. F. Pierce,
E. L. Sinclair,
C. U. Smith,
E. W. Smith,
John Stewart,
D. G. Tewksbury,
T. B. Turnbull,
G. H. Webb,
C. F. Weir,
F. M. Wherren,
J. J. Wishart,
J. P. Yates.

Total number of members registered, 159.

Charter members present; W. A. McGonagle, A. S. Markley, A. McNab and G. E. Hanks.

Past-presidents in attendance; W. A. McGonagle, A. S. Markley, W. A. Rogers, W. S. Danes, C. A. Lichty, J. B. Sheldon, R. H. Reid, J. P. Canty, H. Rettinghouse, F. E. Schall, A. E. Killam and J. N. Penwell.

The President:—Next in order is the reading of the minutes of the last meeting, but as they have been published and every member has had access to them it will not be necessary to have them read at this time. If there are no additions or corrections they will stand approved.

The next order of business is the election of new members. We will now have the report of the membership committee.

REPORT OF COMMITTEE ON MEMBERSHIP.

Your membership committee has had an active season, and has the pleasure to report a number of new members from various parts of the country. The committee has been assisted materially by many members of our association. Particularly our secretary has rendered invaluable aid in this direction.

There is difficulty in reaching active bridge and building men, owing, in many cases, to their addresses not being listed. This is called to attention that each member of our association may and is urged to give personal aid by forwarding such addresses to the committee. In many cases very active members might be secured and the benefits of our association could thus be shared by these men, and the railway systems under whom they are employed.

The following list of applicants is presented for your consideration, and their respective elections to membership is recommended by the committee.

A. A. Horning,
Chairman.

LIST OF APPLICANTS FOR MEMBERSHIP.

Airmet, E. S., For. Ptr., O. S. L. R. R., Salt Lake City.
Althof, L. W., Asst. Br. Engr., O. S. L. R. R., Pocatello, Idaho.
Barber, N. N., Asst. Engr., C. M. & St. P. Ry., Ottumwa, Iowa.
Beeler, C. L., Asst. Eng., N. Y. N. H. & H. R. R., New Haven, Conn.
Black, G. W., Div. For. B. & B., Ill. Trac. Sys., Mackinaw, Ill.
Blake, L. M., Supv. B. & B., B. & M. R. R., St. Johnsbury, Vt.
Bock, J. G., Gen. Br. Insp., C. St. P. M. & O. Ry., St. Paul, Minn.
Boyer, Grant, Div. For. B. & B., M. C. R. R., Detroit, Mich.
Bridges, T. H., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Brookhart, N. D., Asst. Supvr. B. & B., O. S. L. R. R., Pocatello, Idaho.
Brown, Thos., Br. Insp., P. M. R. R., Saginaw, Mich.
Buckley, J E., Supvr. B. & B., B. & M. R. R., Nashua, N. H.
Byrd, J. E., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Byrd, W. E., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Candee, Eldridge E., Dist. Br. For., N. Y. N. H. & H. R. R., Bridgeport, Conn.

Candee, Elliot E., Dist. Br. For., N. Y. N. H. & H. R. R., Waterbury, Conn.
Copp, J. P., Mast. Carp., C. R. I. & P. Ry., Haileyville, Okla.
Counts, D. E., Supv. B. & B., W. & A. R. R., Dalton, Ga.
Cowsert, L. A., Supv. W. S., C. N. O. & T. P. Ry., Danville, Ky.
Crawford, J. A., B. & B. Mast., Can. Nor. Ry., Saskatoon, Sask.
Cullen, F. P., For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Danes, E. C., Gen. For., Wabash R. R., Peru, Ind.
Demars, E. A., For. W. S., O. S. L. R. R., Salt Lake City.
Dittmar, F. C., Br. For., Sou. Pac. Co., Los Angeles, Cal.
Duckett, W. E., Asst. Engr., C. M. & St. P. Ry., Minneapolis, Minn.
Dufort, S. E., Gen. For. B. & B., B. & M. R. R., Lowell, Mass.
Esping, Chas., Mast. Carp., B. & O. C. T. R. R., Chicago.
Evans, J. J., Supv. Signals, P. M. R. R., Saginaw, Mich.
Fair, E. W., Supvr. B. & B., B. R. & P. Ry., Du Bois, Pa.
Fenwick, G. H., Gen. Br. For., M. C. R. R., St. Thomas, Ont.
Fitzgerald, J. M., Supvr. B. & B., C. of G. Ry., Macon, Ga.
Gable, Franklin, For. Carp., P. & R. Ry., Catawissa, Pa.
Gaby, F. A., Ch. Engr. P. C. of Ont., Toronto, Ont.
Galloway, W. J., Mast. Carp., S. A. L. R. R., Hamlet, N. C.
Gardner, E. F., Mast. Carp., Erie R. R., Buffalo, N. Y.
Garner, R. D., Engr. Const., S. N. E. Ry., Providence, R. I.
Gaunt, Fred, Ptr. For., O. S. L. R. R., Pocatello, Idaho.
Gauthier, A. I., Supvr. B. & B., B. & M. R. R., Concord, N. H.
Gilman, A. F., Asst. Engr., C. St. P. M. & O. Ry., St. Paul, Minn.
Glasgow, J. F., Gen. For. B. & B., C. St. P. M. & O. Ry., Worthington, Minn.
Gradt, Chas., Ch. Carp., C. M. & St. P. Ry., Savanna, Ill.
Haley, W. S., Res. Engr., N. Y. C. R. R., Toledo, O.
Hansen, Rupert, For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Harlow, A. W., Mast. Carp., Erie R. R., Huntington, Ind.
Harshbarger, C. A., Asst. Br. For., O. S. L. R. R., Ontario, Ore.
Hodges, F. J., C. C., M. C. R. R., Jackson, Mich.
Huntoon, J. S., Ch. Br. Insp., M. C. R. R., Detroit, Mich.
Innes, J., Gen. For., G. T. Ry., Hamilton, Ont.
James, R. E., Supv. B. & B., L. V. R. R., Hazelton, Pa.
Johnson, C. H., For. B. & B., P. M. R. R., Saginaw, Mich.
Johnson, Maro, Asst. Engr. B. & B., I. C. R. R., Chicago.
Kelly, J. A., Gen. For. Br., O. S. L. R. R., Pocatello, Idaho.
Kulp, B. R., Div. Engr., C. & N. W. Ry., Antigo, Wis.
Lanning, W. R., Ch. Carp., C. M. & St. P. Ry., St. Maries, Idaho.
Lentz, C. W., Supv. B. & B., I. C. R. R., Dubuque, Iowa.
Leslie, Andrew, Div. For., M. C. R. R., St. Thomas, Ont.
Lewis, E. R., Asst. to G. M., D. S. S. & A. Ry., Duluth, Minn.
Loeffler, M., Supv. Br., L. I. R. R., Jamaica, N. Y.
Lutken, P. K., Gen. For. B. & B., N. O. M. & C. R. R., Laurel, Miss.
McCabe, E. M., Supv. B. & B., B. & A. R. R., Pittsfield, Mass.
McDonald, Hunter, Ch. Engr., N. C. & St. L. Ry., Nashville, Tenn.
McKay, A. G., Div. For. Bldgs., N. Y. N. H. & H. R. R., New Haven, Conn.
McNaughton, H. C., Div. For. B. & B., B. & M. R. R., Concord, N. H.
Middleton, R. J., Val. Engr., C. M. & St. P. Ry., Chicago.
Mines, Chas., Gen. For. B. & B., C. St. P. M. & O. Ry., Emerson, Nebr.
Morgan, Homer, For. B. & B., P. M. R. R., Greenville, Mich.
Mulcahy, W. H., For. B. & B., C. & N. W. Ry., Adams, Wis.
Newton, E. O., Div. For. Bldgs., N. Y. N. H. & H. R. R., Danbury, Conn.
Nies, A. B., Archt., M. C. R. R., Jackson, Mich.
Noland, W. B., Supvr. B. & B., O. A. & E. Ry., Sacramento, Cal.
Owen, John, For. B. & B., D. & M. Ry., East Tawas, Mich.
Paterson, E. E., Plumber For. O. S. L. R. R., Pocatello, Idaho.
Pierce, Roy, Mast. Carp., Erie R. R., Salamanca, N. Y.

Piper, E. B., For. B. & B., B. & M. R. R., Fitchburg, Mass.
Pitcher, C. G., For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Secord, Fred, For. B. & B., Sou. Pac. Co., Sacramento, Cal.
Self, E. P., Supv. Bldgs., L. I. R. R., Jamaica, N. Y.
Sellew, W. H., Valuation Dept., M. C. R. R., Detroit, Mich.
Shifflit, Parker, For. Br. Erec., O. S. L. R. R., Pocatello, Idaho.
Sinclair, E. L., Asst. Engr., C. M. & St. P. Ry., Marion, Iowa.
Smith, C. U., Asst. Engr., C. M. & St. P. Ry., Milwaukee, Wis.
Smith, E. W., Architect Val., M. C. R. R., Detroit, Mich.
Smith, Wm., For. W. S., St. L. I. M. & S. Ry., McGehee, Ark.
Snyder, A. M., Supv. B. & B., L. & N. E. R. R., Pen Argyl, Pa.
Sorensen, Wm., For. B. & B., O. S. L. R. R., Brigham, Utah.
Stewart, John, Gen. For. B. & B., C. St. P. M. & O. Ry., Spooner, Wis.
Stone, L. W., Supvr. B. & B., N. Y. C. R. R., Oswego, N. Y.
Strothers, R. R., Asst. Engr., C. St. P. M. & O. R. R., St. Paul, Minn.
Tewksbury, D. G., Supvr. B. & B., St. L. I. M. & S. Ry., Gorham, Ill.
Thomas, M. E., Div. Engr., C. & N. W. Ry., Boone, Iowa.
Thorn, S. B., Div. For. Bldgs., M. C. R. R., Bay City, Mich.
Turnbull, T. B., Supt. B. & B., A. A. R. R., Owosso, Mich.
Webb, Geo. H., Ch. Engr., M. C. R. R., Detroit, Mich.
Weir, C. F., Supvr. B. & B., P. M. R. R., St. Thomas, Ont.
Wherren, F. M., For. B. & B., B. & M. R., Portsmouth, N. H.
White, F. W., Supvr. B. & B., L. V. R. R., Sayre, Pa.
Whitmee, G. Y., For. W. S., P. M. R. R., Grand Rapids, Mich.
Wishart, J. J., Supvr. B. & B., N. Y. N. H. & H. R. R., Hartford, Conn.
Yates, J. P., Gen. For. B. & B., N. O. T. & M. R. R., DeQuincy, La.

Total number of applicants, 99.

The secretary was authorized to cast one vote, electing the applicants members, whereupon they were declared entitled to all rights and privileges of the association.

REPORT OF EXECUTIVE COMMITTEE.

The first committee meeting occurred at the Congress hotel, Chicago, March 17, 1915, at 4:30 P. M. The members present were, L. D. Hadwen, C. E. Smith, F. E. Weise, Lee Jutton, W. F. Strouse, C. R. Knowles, Arthur Ridgway and C. A. Lichty. Others present included O. F. Dalstrom, A. S. Markley, J. H. Markley, R. H. Reid, P. J. O'Neill, F. E. Schall, P. P. Lawrence, J. N. Penwell, M. Riney, A. McNab and J. D. Black.

The meeting was called to order by President Hadwen. F. E. Weise stated that, in his opinion, it would be best to combine the office of secretary and treasurer and have one bond cover both positions. A motion was made to the effect that an amendment to that effect be proposed to the next convention. The motion carried. J. P. Wood reported on the hotel situation at Detroit for the coming convention, stating that the committee on arrangements had canvassed the hotels and would recommend that the headquarters be made at the new Hotel Statler. It was decided that the president and secretary should, if possible, make a trip to Detroit, and, with the committee, make necessary arrangements for hotel accommodations, convention hall, etc.

The time of year in which our annual conventions were being held came up for discussion and the secretary was instructed to secure a poll of the members indicating if a change was desired, the result to be made known at the next convention.

It was decided that the investing of surplus funds in the hands of the treasurer be done at the discretion of the president, secretary and treasurer. The subject of the entertainment of our members at conventions was freely discussed but no final action was taken. It was the consensus of opinion that as far as possible it would be better to furnish our own entertainment hereafter, receiving assistance only from cities in which the conventions are held.

The secretary was authorized to expend such funds as necessary to furnish the office with the required furniture, etc. He was also authorized to join the Society of Technical Associations' Secretaries, (the dues to be paid by the association) after which the meeting adjourned.

A meeting was held at the Hotel Statler, Monday evening, Oct. 18, 1915, at which were present L. D. Hadwen, Geo. W. Rear, S. F. Patterson, C. R. Knowles and C. A. Lichty. Others present were W. A. McGonagle, J. N. Penwell, W. O. Eggleston, P. J. O'Neill, and J. P. Wood. The meeting was called to order by President Hadwen. It was moved that the president appoint a representative to be present at the second Pan American Scientific Congress to be held at Washington, Dec. 27, 1915 to Jan. 8, 1916, with the view that some resident member be named if possible. The motion carried. The question was raised regarding the advisability of having volumes 2, 3 and 4 of the proceedings reproduced for the benefit of those who were unable to secure them at present. The secretary stated that several later numbers had become exhausted, and that it would be considerable expense to reproduce all of the back numbers that were exhausted or nearly so. The matter was left for the secretary to ascertain how many members really desired to purchase back numbers and to have an estimate made as to the probable expense of having some of the numbers prepared, with final action to be taken later.

The chief topic for discussion was that pertaining to the entertainment of the members and their families during their stay in the city. There being no further business to come before the meeting it was adjourned subject to the call of the president.

C. A. Lichty, Secretary.

REPORT OF THE SECRETARY.

Chicago, Oct. 16, 1915.

Twelve hundred copies of the proceedings were issued, 800 with cloth covers and 400 with paper covers. Three numbers of the Bulletin were issued during the fiscal year.

Total number of members reported last year,	557	
New members, 1914,	45	602
Deceased,	14	
Resigned and dropped,	19	33
Total number of members, Oct. 18, 1915,		569
New members enrolled at Detroit convention,		98
Total number of members Oct. 23, 1915,		667

FINANCIAL.

Receipts.

Badges,	$ 36.00	
Dues and fees,	1,101.00	
Advertising,	1,302.90	
Sale of books,	49.90	$2,489.80

Disbursements.

Badges,	$ 60.80
Postage,	100.64
Printing and engraving,	1,117.41

Stationery and office supplies,	$ 22.77	
Drafting,	35.50	
Editing,	65.00	
Stenographer,	110.00	
Expenses of various committees,	52.81	
Salaries and office rent,	800.00	
Los Angeles convention expenses,	122.20	
Telegrams, express and exchange,	8.50	
Miscellaneous,	17.50	
	$2,513.13	
Deficit from last year,	94.26	$2,607.39
Deficit, 1915,		$ 117.59
Balance due from advertising,	$ 137.50	

C. A. Lichty, Secretary.

REPORT OF THE TREASURER.

Balance on hand as shown by treasurer's report October 20, 1914,	$1,169.42
Additional interest up to time funds were turned over,	7.40
Amount received from J. P. Canty (former treasurer),	$1,176 82
April 28, 1915, Purchased nine $100 notes of the Windsor Golf Club,	913.05
	$ 263.77
Received as interest,	32.96
Cash on hand October 20, 1915,	$ 296.73
Assets—Notes of Windsor Golf Club,	900.00
Total Assets,	$1,196.73

The above report does not include the accrued interest on the bank deposit from July 1 and on the notes from August 1, 1915.

Respectfully submitted,

F. E. Weise, Treasurer.

The President:—The chair will appoint J. S. Robinson, R. C. Sattley, and O. F. Dalstrom as a committee to audit the accounts of the secretary and the treasurer, and J. B. Sheldon, J. N. Penwell, and H. Rettinghouse as a committee on resolutions. I will also appoint F. E. Weise assistant secretary.

We will next listen to the report of the committee on relief.

REPORT OF COMMITTEE ON RELIEF.

The committee on relief has had but one application during the past 12 months. This is a very satisfactory record, considering that business has been rather slack for the past two years.

Respectfully submitted,

Arthur Montzheimer, Committee.

REPORT OF OBITUARY COMMITTEE.

It is with profound regret that we must announce that the year just passed since our last convention has been the most unfavorable for us in all of our history because of the activities of the great reaper, Death. With deepest sorrow in our hearts we realize that the long list includes our beloved first president, our first vice-president, and our oldest member. Yet in our sorrow and affliction we would not murmur against the Hand that has bereaved us, but realize that our Father in his wisdom doeth all things well. While we can but mourn most deeply and sincerely for these, our beloved brothers, let us turn for comfort and consolation to our God who has thus far given us all of our blessings and realize that he never afflicts willingly, and that his Grace is sufficient to our need.

Resolved that this association tenders its heartfelt sympathy and condolence to the widows and families of these, our deceased brothers, in their bereavement with an earnest prayer that our loving Heavenly Father may comfort them in their afflictions, and that it be further resolved that these resolutions be entered in our proceedings, and a copy thereof be sent to each of the respective families.

Respectfully submitted,

B. F. Pickering, Committee.

The President:—This completes the formal business of this morning's session. The first of the regular committee reports will be presented promptly at 2 o'clock. Let me emphasize what I said before regarding our being prompt in attendance. We have a very full three days before us, and we ought to make use of every minute of our business sessions to the fullest advantage. We can only do this by being on hand at the stroke of the clock and attending to business until the end of the session, after which we can go to any outside attractions. Don't let us have any interruption to the business meetings. Let us meet promptly on time, and we will endeavor to break up promptly, so as to leave ample time to take in any of the excursions provided for us. If there is nothing else to be presented at this time the meeting will stand adjourned until two o'clock.

AFTERNOON SESSION.

Tuesday, Oct. 19, 1915.

The secretary called the attention of the members to the blanks that were distributed which would enable those eligible to secure a half rate refund from the Pullman Company providing the rules were complied with as designated in the blanks.

The President:—The next order of business is the reading and discussion of the committee reports. I will ask the assistant secretary to distribute the printed copies of the report on Subject No. 1—the Use of Locomotive Cranes. I will call on

Mr. Rear, the chairman of the committee, to read such portions of the report as may be necessary. (See report and discussion of Subject No. 1.)

The report on Subject No. 2, Pile and Timber Trestle Bridges, was next taken up and was read by the chairman, Mr. McVay. (See report and discussion.)

About the middle of the afternoon the discussion of Subject No. 2 was carried over until Wednesday morning to permit C. R. Knowles to present his paper on Water Waste, arrangements having been made previously to have a lantern operator on hand at a specified time. (See paper and discussion on Water Waste.)

F. E. Weise occupied the remainder of the afternoon session with the presentation of a special paper on Manilla Rope.

The meeting adjourned until 9 o'clock Wednesday morning.

MORNING SESSION.

Wednesday, Oct. 20, 1915.

The meeting was called to order at 9 a. m., with President Hadwen in the chair.

REPORT OF COMMITTEE ON NOMINATIONS.

We are called upon to fill the vacancy caused by the death of our first vice-president. Mr. Aldrich was a loyal worker and a faithful member of the association and his loss will be felt by many. Mr. Steffens stated that he did not desire to be advanced. Because of these and other reasons the committee presents the following list of names for officers for the ensuing year:

For president, G. W. Rear, Southern Pacific; first vice-president, C. E. Smith, Missouri Pacific; second vice-president, E. B. Ashby, Lehigh Valley; third vice-president, S. C. Tanner, Baltimore & Ohio; fourth vice-president, Lee Jutton, Chicago & Northwestern; secretary-treasurer, C. A. Lichty, Chicago & Northwestern. For executive members: F. E. Wise, Chicago, Milwaukee & St. Paul; W. F. Strouse, Baltimore & Ohio; C. R. Knowles, Illinois Central; Arthur Ridgway, Denver & Rio Grande; J. S. Robinson, Chicago & Northwestern, and J. P. Wood, Pere Marquette.

Respectfully submitted,

R. H. Reid,
F. E. Schall,
S. F. Patterson,
J. N. Penwell,
Committee.

E. S. Meloy, of the Chicago, Milwaukee & St. Paul, was also nominated for the office of treasurer if the amendment which provided for the merging of the offices of secretary and treasurer was not adopted.

The discussion of Subject No. 2 was resumed where it had been dropped the day before. When Subject No. 2 was disposed of the president called on C. R. Knowles to present Subject No. 3—Railway Water Tanks. Mr. Knowles read extracts from the report after which it was discussed. (See report and discussion.)

After the discussion had continued for some time H. Rettinghouse suggested that on account of lack of time it might be better to proceed to the subjects to follow and allow those who desired to send in further discussion in writing to be incorporated in the proceedings, and put this in the form of a motion. Jas. Dupree and A. S. Markley thought it better to take more time in the meeting on this subject and the motion being put to a vote was lost. The discussion was continued.

R. C. Sattley stated that he was pleased to note that the committee had taken up the subject of costs to a considerable extent. He stated that nearly every subject that was brought up was decidedly lacking as to costs while that phase of the work was a vital one at the present time when all of the roads were interested in compiling data for the department of valuation.

G. W. Rear was next called upon to present his paper (not printed in advance) on Subject No. 6—Efficient Methods of Handling Work and Men. The paper elicited considerable applause but was not discussed. Before reading the paper Mr. Rear made the following remarks:

Mr. Rear:—I might say that this paper is the result of a great deal of study, and while very few of those present may agree with it entirely on first thought I think that after you have studied it you will agree with me. We seem to have a very timid lot of members, for in sending out letters to gather information on the subject I failed to get any response, everyone appearing to be a little afraid to advance his particular method of doing work for public criticism. We decided that, for this year, we would not attempt to show any specific examples of work, but would take up the subject from the standpoint of handling men and work in a general way, thinking that after this had been read and the matter had been given further thought here, we would be flooded with specific examples of the work. We already have one which came in since I came here, and it may be that we will include it in this year's report. As I said, this report is the result of a large amount of study and I don't want you to take snap judment on it from first hearing it read.

The President:—Mr. Rear has prepared such an able report on this subject that it is hardly suitable for discussion at this time. It is food for thought, and if we will all go home and think it over, we will receive some benefit from it at our next convention.

J. P. Wood:—I very much admire that paper, but it doesn't go far enough; it simply reaches the supervisors of bridges and buildings here today. I would like to see that paper placed in the hands of the general manager of every railroad in this country that is represented in the American Railway Bridge & Building Association. We know what we want, but the trouble is to get these facts before them. I believe that if this paper was placed in the hands of the general managers it would open their eyes to the conditions that exist, which they could remedy if they would. If it is in order, I would move you, Mr. President, that copies of this paper be sent to the general manager of each and every railroad represented in this association.

After a brief discussion, the motion was amended to permit the technical journals to publish the paper, instead of sending it direct to the general managers, and in this form the motion was adopted, after which adjournment was taken until 8 a. m.

AFTERNOON SESSION.

Wednesday, Oct. 20, 1915.

The afternoon was devoted to a trip by special train on the Michigan Central through the Detroit river tunnel to the Canadian side and return, thence via the belt line around the city to the Ford Automobile plant where the train was left. After an interesting trip through the Ford plant the party returned to the city by trolley cars.

EVENING SESSION.

Wednesday, Oct. 20, 1915.

In the evening a dinner was given in the banquet hall of the Statler hotel, attended by members and their guests to the number of 300, celebrating the 25th anniversary of the association. A number of members gave short talks on the earlier days of the association, and reminiscences were indulged in by many of the older members. Among those present were four charter members—W. A. McGonagle, A. S. Markley, A. McNab, and G. E. Hanks—and 12 past presidents—W. A. McGonagle, A. S. Markley, W. A. Rogers, W. S. Danes, C. A. Lichty, J. B. Sheldon, R. H. Reid, J. P. Canty, H. Rettinghouse, F. E. Schall, A. E. Killam, and J. N. Penwell. President Hadwen acted as toastmaster.

MORNING SESSION.

Thursday, Oct. 21, 1915.

The meeting was called to order at 8: 30 a. m. with President Hadwen in the chair.

The President:—The first paper to be taken up this morning will be that on Subject No. 4—Small Coaling Stations. This report was received too late to be printed and I will ask the chairman, Mr. Jutton, to read the report. The chairman stated that, in keeping within the limits of the subject, the committee limited the capacity of the stations considered to 50 tons. (See report and discussion.)

The president next called on Chairman Storck of the committee reporting on Subject No. 7 to present the report on Warnings for Overhead and Side Clearances. (See report and discussion.)

The secretary read several letters and telegrams from absent members who anticipated being present at the convention but were unable, for various reasons, to be there.

The President:—G. A. Rodman, chairman of committee No. 5, is present, but is not in the room at this moment. We will proceed with Subject No. 5—Costs of Structures. (The secretary read the report. See report and discussion.)

In the absence of Mr. Dalstrom, chairman of the committee on Subject No. 8—Reinforced Concrete Bridge Work, the report was read by the secretary.

Instead of the discussion following this subject the time was devoted to a short paper by Harold P. Brown, of New York City, entitled Steam Jetted Concrete. (See paper following the report.)

The President:—There has been no report presented on Subject No. 9—Station Buildings for Passenger Service only. The chairman, M. A. Long, stated that he did not have the material in proper shape and requested that the subject be carried over. The committee has collected considerable material that is of value and it is hoped that the report may be presented in complete form for the next convention. We will therefore pass to Subject No. 10—Concrete Culvert Pipe and Concrete Piles. (The chairman, H. Rettinghouse, read the report. He called attention to the fact that it is the general practice that our association depends almost entirely upon the chairmen of the committees to get out the reports. See report and discussion.)

Subject No. 11—Street Crossing Gates, Towers, Bells, etc., was next presented. (See report—no discussion.)

The President:—This disposes of the subjects for report and discussion. We will take up the matter pertaining to the proposed amendment to the Constitution and By-laws. We have before us an amendment whereby it is proposed to combine the offices of secretary and treasurer. As the constitution now stands the treasurer's office is largely a nominal one, as the funds of the association are simply put in the treasurer's care. There seems to be no reason why the secretary should not be bonded and assume that responsibility and thereby avoid the confusion which arises when the secretary and the treasurer are not located where they can be in close communication, as has sometimes been the case in the past.

G. W. Rear:—I move that the offices of secretary and treasurer in this association be combined and that the secretary-treasurer be bonded according to the notice sent out. I am very much opposed to combining the two offices, but at the same time I do think that the secretary should be bonded, without casting any reflections on our present secretary or any future secretary. If it is going to facilitate matters to have the two offices combined, I will favor it on that understanding only.

The motion was then adopted.

The President:—The motion is carried, the constitution will be amended accordingly and the revised constitution will be printed in the proceedings when they go out.

We will next have the report of the committee on subjects for the year 1915-16.

REPORT OF COMMITTEE ON SUBJECTS.

It is a great privilege as well as a responsibility to act on the committee for the selection and recommendation of subjects for this association. The American Railway Bridge and Building Association is an organization of railroad men engaged in a line of work, the importance of which is second to none in the operation of a railroad. The work of these men must be done carefully and conscientiously in order that trains may be operated with safety and dispatch. Railroads can not do otherwise than place such work in the hands of competent and reliable men, and, therefore, the fact that the members of this association hold the positions they do is in itself their best recommendation.

We meet for the interchange of ideas and experiences, and in order that the benefit of such meetings may be as far-reaching as possible, we not only get together to talk things over, but we appoint committees to make investigations and reports and have these as well as the discussions thereon published in the proceedings, making them available to the members who are unable to attend the meetings and to others as well.

The members who are active in committee work are the ones who reap the greater benefits, because committee work enables one to gather more information than can be put into the reports, and it is an excellent training in the systematic study of a subject. Every member who has undertaken committee work will support the statement that it gave him much profit and pleasure personally, and made him a better man in his position.

We, therefore, urge new members to welcome committee work when it is offered them and not to hesitate to accept because of lack of experience. It is true that it can not be done without the investment of time and effort, but such an investment will return good dividends.

The committee presents for your consideration the following list of subjects for the year 1915-16, and recommends its adoption.

NEW SUBJECTS.

1. Brick, cement, asphalt and wood block floors for shops, roundhouses, freight houses, highway bridges, etc.
2. Paint and its application to railway structures.
3. Fireproofing roofs of wooden buildings.
4. Water Supply (a) Intakes and intake lines. (b) Internal combustion engines.
5. Caring for and handling creosoted material.
6. Blank Forms for Bridge and Building Department Use.
7. Modern methods of driving piles.
8. The economical handling of concrete on the smaller jobs.
9. Efficient methods of handling work and men.
10. Station buildings for passenger service only.
11. Small coaling stations.

F. E. Weise,
C. E. Smith,
E. C. Morrison,
Committee.

The President:—If there are no objections this report will be adopted.

I wish to make one point clear; the secretary was instructed to cast the ballot for all the applicants found eligible by the committee on membership and voted accordingly. There was possibly some misapprehension about some of the most recent applicants but the motion was so worded as to cover any applications received since the commencement of our convention.

There is one question that should be brought up—the election of life members. It has been our practice to honor with life membership, certain of our oldest members who are perhaps no longer in active railway service, but who should continue to be members of the Association.

The Secretary:—I should like to say a word on this subject. You will notice by referring to our proceedings that we have a pretty fair list of life members. I think sometimes that we ought to distinguish between members who are placed on the life membership list on account of age and inability to pay dues, and those who are elected as an honorary degree. I think we should revise our constitution sometime to that effect. We lost five of our life members in the past year by death. I don't think we ought to elect a great number of life members every year, and we should elect no one to this honorable degree until his name has been brought before the association and some good reason given for his election.

I present the names of the following members for life membership: E. Loughery, J. O. Thorn, S. D. Bailey, A. Shane, W. B. Mackenzie, and A. H. Beard.

Mr. Beard stated that he preferred to retain the title of an active member. The other five were elected to life membership upon motion by J. P. Wood.

The President:—The next order of business is the election of officers. We have the report of the nominating committee which was presented yesterday. (The secretary read the report.)

Upon motion of Mr. Rettinghouse the secretary emeritus was instructed to cast the ballot of the association for the officers named in the committee report, whereupon they were declared elected.

President Hadwen:—I now come to the point in the proceedings where I can relinquish the cares of office to my successor who, I know, will make the next year a very successful and prosperous one for the association. He has amply demonstrated to you all how fittingly he can fill this office which I esteem one of the most honored in a technical or non-technical gathering. Mr. Rear, I hand you the insignia of office. (Presenting the gavel.)

(President Rear takes the chair.)

President Rear:—Mr. Retiring President and Gentlemen: It is neither the practice nor is it seemly that the incoming president should make any extended remarks at this time. I must say, though, that there is no one in this association who feels more keenly the cause for my being elected president this year as it was really owing to the untimely death of one who should have assumed this office. I know that everyone here feels from the bottom of his heart as I do. However, it is a matter over which we have no control. In assuming this office I do so feeling that it is an honor which I probably do not deserve, but one which I am very glad to take up. I consider that the presidency of this association is probably the greatest honor that can be conferred on any man following our profession.

In taking up the work for the next year, I know that each and every one will take hold of it with the same feeling that he has taken hold of it in the past. I feel personally that our committees have been a little too large. It is a fact that the chairman of the committee does most of the work. This entails a large amount of correspondence and work, and a great amount of delay in getting the reports together. In appointing the committees for the next year, I have in mind the selection of smaller committees and of enlisting the coöperation and help of every member in the association for every committee.

There are one or two things which engage the attention of the profession which we follow at this time. In the past we have designed our bridges and trestles mainly for the purpose of transporting trains over them with the trains on the rails, but we all know that there are many occasions where trains, especially of freight cars, go over our structures on the ties. From a Safety First standpoint, this detail of bridge construction must be given a great deal of attention in the future. I do not care to take any more of your time because we are very short of that article, which, when once passed, we cannot bring back. Some of the officers who have been elected are not present, but I would ask those who are here and whose names I call, to rise and signify their intention or willingness to accept the office.

(The President then called the names of Messrs. Tanner, Jutton, Lichty, Knowles, Robinson, and Wood. Each in turn signified his willingness to accept.)

The President:—Next in order is the selection of a place to hold our next convention.

A. S. Markley nominated New Orleans, Mr. Storck, Philadelphia, and Mr. Rettinghouse nominated St. Paul.

The president stated that if there were no further nominations the convention would proceed to ballot.

The vote resulted as follows: New Orleans, 69; Philadelphia, 2; St. Paul, 33. The chair declared that New Orleans having received a majority of the votes cast would be the next meeting place.

The President:—The next in the order of business is the presentation of the report of the committee on resolutions.

REPORT OF COMMITTEE ON RESOLUTIONS.

Resolved: That the thanks of this association be extended to the following individuals and corporations:

To the mayor of the city, Oscar B. Marx, for his address of welcome;

To J. C. Bills, general solicitor for the Pere Marquette, for his able address to the convention;

To the committee on arrangements for the excellently arranged program for the entertainment of our members and guests;

To the officers of the Michigan Central for the courtesy extended in conducting the members and guests on the tour of inspection of the tunnel and terminal yards;

To the various railroads and the Pullman Company for favors granted members and their families en route to and from the convention;

To the management of the Hotel Statler for, the use of the convention hall and the courteous treatment extended to our members and guests;

To the Ford Automobile Co., for the invitation to visit its plant;

To the Railway Supply Men's Association for its coöperation with the local committee in providing entertainment for our members and their families;

To the chairmen and the members of the various commitees and all those assisting them in the preparation of the work for the year.

J. B. Sheldon,
J. N. Penwell,
H. Rettinghouse,
Committee.

There being no further business the twenty-fifth annual convention was adjourned, the next meeting to be held at New Orleans, Oct. 17, 1916.

AFTERNOON SESSION.

In the afternoon, after adjournment, the members and their friends were invited for a boat ride on the river which occupied the time up to six o'clock.

G. K. Anderson,
Reporter.

C. A. Lichty,
Secretary.

MEMOIRS.

JOHN FORBES.

John Forbes was born at Birmingham, England, January 26, 1834, and died at Halifax, Nova Scotia, June 18, 1915, being then in his 82nd year.

His father, William Forbes, and grandfather, John Forbes (both of Aberdeenshire, Scotland), went to Nova Scotia while the former was a young man, but William returned to England and there married. He was a jeweler by trade. The family went to Halifax when John was about nine years old, sailing in the barque "Manchester," the voyage requiring 58 days. For a time they lived with the grandfather, who was a military man. The father worked as a jeweler, but later he secured a government appointment. He died some years after, and John Forbes then became a clerk in a hardware store. He had a strong liking for mechanical work and was of an inventive nature, and after about seven years he went to the United States, working as a mechanic, and later became interested in the manufacture of spring skates. In 1857 he married Henrietta Jane Scott.

In 1860 he returned to Halifax with his wife and two boys. He became interested in manufacturing in a small way, and when the Starr Manufacturing Co. was formed in 1866 he had charge of the mechanical department. The company made skates at first and then branched out into other lines. The skates were made under John Forbes' patents and he held patents on several machines used in the plant. Between 1875 and 1880 the company took up structural steel work, and Forbes educated himself in this as his special line of work, in which he became very proficient. After being with this company for 25 years, he took a rest for about two years, and then entered the employ of the Intercolonial railway, as bridge engineer. With declining years and impaired health he finally retired from active work, but spent much of his time in a little workshop at his home in Halifax.

He is survived by his wife and six children (four boys and two girls). All the children are married, and there were several grandchildren and great grandchildren. He had been married 58 years in March, 1915, and his death was the first break in the family.

Mr. Forbes joined the association in 1906.

JOHN EWART.

(By Joseph A. Ewart.)

John Ewart was born in Manchester, Eng., Feb. 20, 1841, of Scotch parents, and came to this country when a boy. He received his education in the schools of East Boston, Mass. At the outbreak of the civil war he enlisted in the 29th regiment of Massachusetts volunteers and served through the entire war, being discharged on July 29, 1865, with the rank of second lieutenant. He participated in 21 battles, including Fair Oaks, Malvern Hill, Second Bull Run, Vicksburg, Cold Harbor and Petersburg. He was married at Lawrence, Mass., on June 4, 1867 to Sarah J. Bailey, whose father, John Bailey, was connected with the old Boston & Maine railroad for 50 years, being master of maintenance of way at the time of his death.

John Ewart.

Mr. Ewart died at his home on Newman Way, Arlington, May 10, 1915. He is survived by his wife, three sons and a daughter. He entered the employ of the Boston & Maine soon after the close of the war and was in its service continuously for 45 years. Those who knew him well realized the fidelity with which he served the road, never sparing himself when he could be of service.

He was in the bridge and building department for several years and had been a regular attendant at the conventions of the association since he joined the association at Milwaukee in 1907.

Mr. Ewart had been commander of Francis Gould Post, G. A. R., of Arlington, of which he was adjutant at the time of his death. He had been a Mason for 51 years, was a charter member of the Royal Arcanum, a member of the 29th Massachusetts Regiment Association, the Northeastern Association of Railroad Veterans, the Northeastern Railroad Club, the American Railway Bridge and Building Association and the Arlington Heights Methodist church.

F. S. EDINGER.

(By Geo. W. Rear.)

Frederick S. Edinger was born in Placer county, California, January 21, 1865, and began his railroad service in 1883 with the Central Pacific railroad, now a part of the Southern Pacific Company. He advanced through various positions until he became general bridge inspector in 1894, which position he held until August, 1905, when he left railroad service to become a member of the Shattuck-Edinger Company, railroad contractors. During the past ten years this company has completed a large and varied amount of heavy construction work, which was directly under Mr. Edinger's supervision. Mr. Edinger was noted for his inventive genius and for the many efficient devices he developed to facilitate railroad work.

F. S. Edinger.

He became a member of the American Railway Bridge and Building Association in 1897, and while connected with railroad work, was an active member, contributing some valuable and interesting reports.

He died suddenly of heart failure in Stockton, Cal., May 18, 1915, and is survived by his wife, daughter and son. He left behind him many enduring structures—monuments to his memory—and his untimely death has been keenly felt by his many associates. He was a man of sterling character and his genial disposition made him the friend of everyone, and made everyone his friend.

G. H. SOLES.

(By D. L. McKee.)

George H. Soles, superintendent of bridges and buildings on the Pittsburgh & Lake Erie railroad and one of Braddock's foremost citizens, died September 20, 1915, in the West Penn hospital. He had been ill several weeks with cancer of the stomach and was removed to the hospital. An operation failed to save his life and his condition grew steadily worse until his death.

Mr. Soles was born in Westmoreland county, Pennsylvania, February 10, 1850. He went to Port Perry, Pa., at the age of 17 and worked as a carpenter in the boat yard there for four years. At the age of 21 he accepted a position in the bridge and building department of the Pittsburgh & Connellsville division of the Baltimore & Ohio railroad which he held for 10 years. After leaving the employ of the Baltimore & Ohio he became master carpenter on the Pittsburgh & Western railroad and remained there 8 years. In 1889 he was appointed superintendent of bridges and buildings on the Pittsburgh & Lake Erie railroad, which position he held at the time of his death.

G. H. Soles.

The funeral was held from the Calvary Presbyterian church and was attended by many railroad men, his foremen acting as pall-bearers. Suffering in silence the ravages of an incurable disease for years, he went his way with dauntless heart and unafraid spirit. None ever heard him complain and his genial good nature was a characteristic which made him beloved by all with whom he came in contact.

Mr. Soles was an elder in the Calvary Presbyterian church of Braddock and an honored member of several fraternal organizations and of the American Railway Bridge & Building Association. He joined the latter association at the Minneapolis convention in October, 1902.

GROSVENOR ALDRICH.

(By G. T. Sampson.)

Grosvenor Aldrich was born in Uxbridge, Mass., on November 12, 1859, and died in Boston, Mass., on July 9, 1915. He had suffered for many years from a duodenal ulcer, and finally submitted to a surgical operation as the only remedy. This was a major operation. He was too weak to withstand the shock and the end came on the evening of the day after the operation at the Emerson hospital, Jamaica Plain, Boston, Mass.

The Aldrich family was descended from Geo. Aldrich, one of the pioneers who came from England and settled in the town of Mendon, Mass., in 1663. Grosvenor Aldrich was the son of the late Grosvenor Aldrich and Johanna Smith Aldrich of Uxbridge, Mass., and passed his boyhood on his father's farm. Because of the death of his father, he was early obliged to seek his own living. Mr. Aldrich started early in life as a bridge builder. In 1878 he secured employment with R. F. Hawkins of Springfield, Mass., at that time one of the leading contractors and builders of Howe truss bridges, and later a builder of iron bridges. Mr. Hawkins was the successor in direct line of the firm of Stone and Harris, the original firm which first began the erection of bridges about 1840 under the patents of William Howe, the inventor of the Howe truss. At the time Mr. Aldrich entered the employ of Mr. Hawkins he had contracts for the erection of a number of long span Howe truss bridges on the New York and New England railroad and Mr. Aldrich thus became acquainted with the railroad and its bridgemen.

Grosvenor Aldrich.

In 1881 he began his railroad service with the New York and New England railroad under S. S. White, master bridge foreman, at Blackstone, Mass., and continued in railroad employ the remainder of his life. The railroad at that time had much construction work in progress. It was then completing its Western extension from Waterbury to the Hudson river, where it connected with the New York, Lake Erie and Western and the New York, West Shore & Buffalo railroads at Newburgh, New York, and opened its line for through traffic between Boston, New England and the West.

The construction of second track, and the purchase of heavy motive power and rolling stock made it necessary to either strengthen or entirely rebuild most of the bridges on the line as well as to reconstruct the water stations and many of the yards and station buildings.

Mr. Aldrich profited well by his opportunities and early gained information and experience which proved his worth in after years. In 1883 he was assigned to the bridge force of the Western division under Nat Randall and took up his residence at Fishkill on Hudson. Upon the resignation of Mr. Randall in September, 1887, Mr. Aldrich was promoted to succeed him as bridge foreman of the Western division, in charge of maintenance and repairs of bridges and buildings between Waterbury, Conn., and Fishkill on Hudson. In this position he gained the confidence and good will of his superiors by his ability and fidelity.

The interchange of freight between the Newburgh yards of the railroads above named on the west bank of the Hudson and the yard of the N. Y. & N. E. on the east side at Fishkill was handled by the powerful steam transfer ferry " W. T. Hart," a large double-ended steel steamer with three tracks on the deck and capable of transferring 24 freight cars at each trip. In the busy seasons it was necessary to operate the steamer day and night, and it was a very important link in the line, on which the regular movement of all through freight east and west was dependent. The efficient maintenance of the transfer bridges and ferry racks was of equal importance and the responsibility for the bridge at Fishkill rested upon Mr. Aldrich. It was a trying position, especially in the winter seasons, when the ice in the river was thick and heavy. On all occasions Mr. Aldrich proved his ability and worth. He had a rare talent in promptly devising ways and means to overcome difficulties in emergencies. It was not until 1890 that a second steel girder transfer bridge was built at Fishkill for alternate use and as a substitute for the Howe truss transfer bridge first built in 1881.

In August, 1896, Mr. Aldrich was promoted to the position of master bridge foreman, succeeding W. R. Carter, deceased, and so continued until the railroad was purchased and absorbed by the New York, New Haven and Hartford in 1898. On October 27, 1898, he received the appointment of supervisor of bridges and buildings on the Providence division of the New Haven. In 1896 he changed his home from Fishkill, N. Y., to Franklin, Mass., and he moved to Readville, Mass., in 1898.

When the division limits were rearranged in March, 1908, Mr. Aldrich was made supervisor of bridges on the Boston and Midland divisions, the mileage over which he had supervision being much increased. It was while in this position that it was his duty to supervise the erection of new steel spans to replace the last of the wooden Howe truss bridges on the Midland division, some of which had performed their duty for 50 years or more. When division limits were again rearranged in May, 1913, Mr. Aldrich was made supervisor of bridges and buildings on the Boston division, with supervision over the extensive docks and terminals at Boston as well as a considerable mileage on each of the three lines which radiated from the city. He continued in this position until his death, attending to his regular duties up to the last hour before he went to the hospital. He went away with courage and fortitude to bear the ordeal, and without hesitation, although he well knew the risk of the operation.

The funeral was held on July 13, 1915, from his home on Albion street, Hyde Park, and the service and burial were with Masonic rites under the direction of Cyprus Commandery of Knights Templars of Hyde Park of which he had been an active member. Many prominent railroad men, employees of the bridge department and members of this association were present.

Mr. Aldrich joined the American Railway Bridge and Building Association at the Quebec convention in October, 1903, and from that time was one of its most active supporters. He took a deep interest in its affairs and early accepted appointment on committees, having served on the Executive board; and, in the line of officers from year to year rose to be the First Vice-President at the time of his decease.

On November 25, 1885, he married Miss Ellen Kemble Brooks of Cold Spring, New York. He leaves a widow, a daughter, Mrs. Helen I. Scheibel, and a son, Lorin G. Aldrich. Three brothers and one sister also survive him.

For the last years of his life Mr. Aldrich was an example of courage and fortitude, under the discouraging conditions of his painful affliction; yet with a fine energy and will he gave loyal and faithful service to his employer, the railroad, to the last day. Efficient in his department, methodical in business affairs, prompt and punctual in all his appointments, regular and upright in conduct, he conducted his department in an eminently safe and sane manner, winning the respect and good will of all right-minded men. He gave the best that was in him to the service of the railroad.

JOHN FOREMAN.

(By John L. Foreman.)

John Foreman was born in Maxatawney township, Berks county, Pennsylvania, on July 25, 1823. After learning the trade of a carpenter, he came to Pottstown on January 7, 1845, and secured a position at his trade with the Philadelphia & Reading railroad. After the first week of service he was made gang foreman and at the expiration of the first year he was promoted to foreman of the carpenter shop at Pottstown. He continued in the latter position until the spring of 1866, when he

John Foreman.

accepted a position as master carpenter with the Mt. Savage Coal and Iron Company's railroad, which is located in Maryland and West Virginia. After six months' service with the company, he again entered the employ of the Philadelphia & Reading as superintendent of bridges and buildings of the entire system and continued in that position until his eightieth birthday when he was pensioned on July 1, 1903, after a service of 58 years and 6 months.

He was the inventor and patentee of the well-known wooden or iron truss bridge, also an iron bow-string highway bridge, which bears his name. He also invented the truss car side, which was in general use for many years. He designed and constructed the coaling stations at New York, Brooklyn, Boston, New Bedford, Salem, Newburyport, Buffalo and Duluth, and also designed the coaling station for the Oregon Steamship and Navigation Company at Seattle. These coaling stations removed the coal from steam barges and stored or loaded it on cars to be distributed throughout the country. There are many bridges and other structures standing in different parts of the country, which are monuments to his skill.

He was regarded as being a very efficient officer and was considered one of the most careful men in the management of work of the character in which he was engaged. He resided in Pottstown, Pa., until his death on January 7, 1915, in his 92nd year. He had a wide circle of friends in the railroad and business world which he cherished to the end.

Mr. Foreman joined the association at Kansas City in October, 1894, and was made a life member in 1902. He was an ardent supporter of the organization and attended the conventions quite regularly up to a few years ago. When he could not be present he would write a letter stating the reason and wishing the meetings success. His last letter to the association was written in October, 1914, only four months previous to his demise.

ORLA HOUSE ANDREWS.

Orla House Andrews was born in Granville, Washington Co., N. Y., Aug. 5, 1846. His father, Lucius P. Andrews, a farmer and teacher, died when his son was but five years of age. His education was received in the district schools during his early years, and later in the graded schools, at Middle Granville, and the Collegiate Institute, of Fort Edward, N. Y. He showed a taste for building at an early age. He did his first carpenter work on the Middle Granville cheese factory at the age of seventeen. Later he worked for a season constructing houses which Jay Gould erected in Middle Granville for the employees of his slate quarry at that place.

Mr. Andrews began his railroad work on the Rutland and Vermont railroad as a bridge carpenter. In 1866 he began work on the Baltimore and Ohio, where he remained until 1869, when he entered the service of the Chicago, Burlington and Quincy which was then building between Burlington and Council Bluffs. He remained in that service until the summer of 1870, when that line of road was completed. He then entered the service of the St. Joseph and Denver City railroad, now the St. Joseph and Grand Island R. R., as bridge carpenter. The road at that time extended from St. Joseph, Mo., to Hiawatha, Kansas. He was promoted to the position of bridge foreman in 1878, and assisted in the completion of the road to Grand Island, Neb. He was promoted to the position of superintendent of bridges and buildings in the spring of 1888, which position he held continuously until his death. From 1891 to 1894 the Grand Island was under the management of the Union Pacific, and during that time Mr. Andrews was occupied in the widening of the gage of the Kansas Central, a branch of the Union Pacific. In 1894 the Grand Island became an independent company again, whereupon he resumed his regular position.

Mr. Andrews died at Rochester, Minn., Aug. 28, 1915, following an operation. He is survived by his wife and one sister, Mrs. A. E. Pepper, of Middle Granville, N. Y. The funeral services were held from his home, 1421 Felix St., St. Joseph, Mo., Aug. 28, and were attended by many employees of the Grand Island railroad. During his long career of more than 48 years of railroad service he made a host of friends, both among officials and subordinates. He was unassuming in his manner, of a noble character, and was highly respected by all who knew him.

O. H. Andrews.

Mr. Andrews was a member of the Masonic fraternity, Knights Templars, 32nd degree, and of the American Railway Bridge and Building Association. He joined the latter association at Philadelphia in the year 1893.

C. W. VANDEGRIFT.

(By J. M. Staten.)

C. W. Vandegrift, an old and highly respected citizen of Alderson, Va., was born in Albemarle Co., Va., April 16, 1841, near the site of the University of Virginia, and died at the Chesapeake & Ohio hospital at Clifton Forge, Va., Sept. 22, 1915. The only education he received was in a log schoolhouse which was furnished with slab seats having pin legs. At the age of 18 he took up the carpenter's trade with his father.

Mr. Vandegrift took part in the war between the states, and in one of the most historical events that preceded that great struggle, being a member of the Monticello Guards of the Virginia Military Company that acted as guard at the execution of John Brown at Charlestown in

1859 for his anti-slavery raid into Virginia, culminating in the capture of Brown and the surviving members of his party at Harper's Ferry. During the war Mr. Vandegrift was once wounded, and was captured and put in prison. Soon after the cessation of hostilities in 1865, he began railroading as bridge carpenter on the Virginia Central railroad, now a part of the Chesapeake & Ohio. He later became supervisor of bridges and buildings, and served the above named road for almost 50 years, until pensioned in 1914.

Mr. Vandegrift married Miss King in 1873, to which union three daughters were born. The widow and two married daughters survive.

He joined the association in 1892 and was elected a life member in 1908.

J. T. McILWAIN.

James Thomas McIlwain was born Nov. 10, 1852, of Scotch-Irish parentage in Peninsula, Summit Co., Ohio. He lived on a farm and attended the schools of that town. In April, 1872, he graduated from Eastman's business college in Poughkeepsie, N. Y. His father was a ship carpenter and joiner. In June, 1873, he entered the service of the Valley railroad as bridge builder and general carpenter. He framed and erected the first bridge on the Valley railroad, now the Cleveland division of the Baltimore & Ohio. In September, 1882, he was promoted to the position of superintendent of bridges and buildings. All bridges and trestles under his charge were constructed of timber, some being Howe truss spans 155 ft. long. For about 15 years he did not have the assistance of an engineer and was compelled to furnish all his own plans and estimates.

J. T. McIlwain.

In connection with his other work Mr. McIlwain constructed all the depots, water tanks and freight houses between Warwick and Chicago

Jct. in 1891, in 60 days, for Ryan & McDonald, contractors. In June, 1902, he was appointed master carpenter of the Cleveland division which was formed by uniting the Valley railroad and the Cleveland, Lorain & Wheeling, and during 43 years' service with this road there never occurred an accident for which he was responsible. He had foremen who had been with him in the service for 25 years.

Mr. McIlwain lived a Christian life and was held in the highest esteem by all in his community. He was married Oct. 4, 1893, to Miss Mary Jones, of Akron, O., who with a daughter Mary, aged 17, and a son James, aged 14, survives him. He died suddenly near his home at Akron, O., Aug. 17, 1915.

He joined this association in 1898 and was a devoted member.

SUBJECT No. 1.

LOCOMOTIVE CRANES.

REPORT OF COMMITTEE.

The locomotive crane is a modern tool, its entire development having taken place within the last 25 years. It was designed to fill the demand for a portable crane that could be moved from place to place around an industrial plant, and at first was mounted on truck wheels and moved over ordinary roads. The first locomotive cranes were of small capacity but from them has been evolved the modern locomotive crane which seems to embody every desirable feature. Future changes will probably be only in size and details of design.

The first locomotive cranes were of two to five tons capacity with short booms of about 15 ft. radius. They were mounted on short car bodies supported by four small car wheels. The propelling gear consisted of sprockets and chains and the term " locomotive " required some imagination.

The first real improvement was the adoption of gearing for propulsion, and this feature has now been developed to such an extent that cranes have been built capable of hauling several cars 20 miles per hour.

The four-wheel car was used exclusively for several years and cranes of 10 and 15 tons capacity were built on them. These cranes could not be hauled in trains, even at slow speeds, and the need of a crane that could be transported readily, led to the adoption of the eight-wheel car about ten years ago, since which time the four-wheel car has been confined to yard work. The use of the eight-wheel car also permitted increasing their weight and capacity until now they are made in sizes up to 60 tons capacity.

The greatest handicap in the development of cranes is the limited width of gage. The wheel-base can be made any reasonable length, providing stability parallel with the track, but the limited width makes it necessary to have a heavy car and sufficient counterweight to prevent the car overturning when loads are lifted at right angles to the track. Even with all the weight that can be applied conveniently, the cranes have their full capacity only at short radius. For instance, a 25-ton crane will handle its full capacity at 12-ft. radius, but will only handle 5 tons at 40-ft. radius, the radius being the horizontal distance from the center of the load to the center pin of the crane.

The use of outriggers, which are provided on the larger cranes, increases the width of the base and adds to the stability at right angles to the track. This increases the capacity considerably, especially in the larger sizes, and is of great advantage when using the crane on track that is not level. They should be used on both sides of the crane when handling heavy loads on poor track, as the breaking of the hoisting cable or the slipping of the hitch may cause the crane to tip over backwards. A modern locomotive crane in capable hands can be used for an endless variety of work. No railroad is so small that one or more can not be kept busy, nor is it necessary to use them every day to make them economical as will be shown by the figures in this report.

Uses of Locomotive Cranes.

Among the common uses to which a crane is put, are the following:

Switching: In almost all cases a locomotive crane can switch the cars that it loads and unloads, doing away with the necessity of having the cars "spotted" with a locomotive. On construction work this will save a large amount of work train expense. In storage yards it will save delays waiting for switch engines.

Hoisting: Within its capacity a crane will do all kinds of hoisting either with one or two lines, and with a long boom, or extensions of a short boom it can place loads, such as roof trusses, etc., high above it.

Swinging: As a crane can swing its boom through a complete circle and the radius can be varied, loads can be picked up and placed anywhere within its radius. This is a great advantage in taking material off cars behind a crane and placing it in cars ahead of the crane, or vice versa.

Handling Buckets: A double-drum crane can operate any two-line clam shell or orange peel bucket and handle ore, coal, gravel or any other material that can be handled with such a bucket.

Handling Scrap, etc.: When a locomotive crane is equipped with an electric generator and magnet, it will handle all kinds of metal, such as scrap, nails and spikes in boxes. The expense of hitching on is eliminated and the cost of handling is greatly reduced.

Pile Driving: A leader truss with regular pile driver leaders has been designed to take the place of the boom on the larger sizes of cranes. This arrangement makes a first-class pile driver capable of doing the work of a regular pile driver, equal to or perhaps a little better, owing to its full-circle swing. Suspended or dangling leaders are often used with the regular crane boom. This is a pretty good makeshift, but is not to be compared to a regular driver.

Bridge or Building Construction: A locomotive crane will switch the cars, unload the material, drive the coffer-dam, make the excavation, drive the foundation piles, handle concrete material, tear out the old structure, erect the new one, and clean up and load the remaining material without the assistance of any other machine and with very few men.

Storage Yards: In a storage yard a locomotive crane will switch the cars, will load, unload and pile material of all kinds, including timber and lumber, coal, scrap, rails, etc., and will pile it higher than is economical by hand.

Ballast Pit: In a ballast pit it will make a good showing loading ballast, especially if the excavation is below the water line.

Roadway Service: On the road it is of great value picking up freight that may have fallen from cars, such as logs, rock, etc. It will pick up and place rip-rap, and will load lumber, rails or any other heavy material. It can be used to good advantage as a light wrecker, being capable of handling freight cars, etc.

Cranes are built in sizes ranging from 3 to 60 tons capacity; the lightest ones being used chiefly around industrial plants and the larger ones for special purposes, such as bridge erection, etc. The best all-around crane for maintenance of way work is the eight-wheel crane of 20 to 30 tons capacity. Such a crane will cost from $7,000 to $8,000. The cost of operation depends on the number of days worked, the kind of work, etc., it being evident that a crane loading ballast will require more repairs than one doing light work in a storage yard. However, the average cost of operation will be about as follows:

Interest	$ 2.00
Depreciation	2.00
Repairs	2.00
Fuel	2.50
Supplies	.50
Labor	6.00
Total	$15.00

This is somewhat higher than is usually claimed but is probably a fair estimate. Where fuel is cheap and wages low, it may be reduced somewhat but it is usual to underestimate such items as depreciation and repairs. Depreciation and repairs have been figured on the basis of a crane being kept in service 20 years, but that in the meantime it will have been completely rebuilt once. The daily rate is based on using the crane 200 full days during the year.

What a crane will earn depends upon the class of work it is doing and the amount saved depends upon the method superseded. For instance, a crane will not switch cheaper than a switch engine, it will not excavate or handle material cheaper than a good stiff-leg derrick, it will not drive piles cheaper than a good pile driver, or compete with any other good machine designed for special purposes. However, when its adaptability is taken into consideration, the fact that it may displace several machines (on account of being able to command a large territory) makes its value evident.

It is when the use of a crane is compared with manual labor that its great saving is shown. Figures have been obtained from a large number of sources and while they show considerable variation in general it may be claimed that a crane will save as against hand work, as follows:

Handling scrap and other material with a magnet	$40 day
Handling coal and other material with a clam shell bucket	40 "
Handling lumber and timber	30 "
On general construction work including switching	40 "

From these figures it will appear that a crane will pay for itself in a year's time.

A few comparative costs selected at random, follow:

Material Handled.	Unit.	By Hand.	With Crane.
Scrap	Ton	.20 to .25 cents	.02 to .06 cents
Coal	"	see note	.05 to .10 "
Timber	M. ft.	.40 to .50 cents	.12 to .20 "
Lumber	"	.40 to .50 "	.25 to .35 "
Piling	Lin. ft.	.004 "	.002 "
C. I. Pipe (Loading)	Cwt.	.032 "	.016 "
C. I. Pipe (Unloading)	"	.021 "	.012 "

Note: The cost of handling coal is not given as coal handled in any great quantity by hand generally has some labor-saving device, such as elevated tracks, etc.

The saving in money is not the only saving that can be credited to the crane, as the liability of personal injuries is much less where heavy material is handled by mechanical means.

A few typical instances of crane work follow:

A large locomotive boiler weighing 25 tons has been picked out of a river bed, hoisted 60 ft. and loaded on a car in 25 minutes. By hand it would have taken two or three days and in this case a work train would have been necessary to handle the car.

A stiff-leg derrick has been set up along-side of a bridge and put into use in three hours. Without a crane it would take all day to unload and place the engine and derrick ready for setting up.

A tower 100 ft. high has been set up with a temporary boom extension in less time than would have been required to rig a gin-pole to do the erection.

At the Panama Pacific Exposition there are a large number of statues ornamenting the buildings. These were placed very cheaply with a locomotive crane, the boom of which had been extended to over 100 ft. This enabled the crane to reach practically all locations and the statues were set up quickly and without damage. To have rigged poles to handle each one would have taken a great deal more time and would have cost much more.

These instances might be continued indefinitely, but others will readily suggest themselves to the practical man. In general however, it may be claimed that a crane will do hoisting where tracks are available, in less time than it will take to rig up any other device.

General Considerations.

The following observations may be of assistance to any one contemplating the purchase of a crane:

The wheels, axles, journals, boxes, brasses, etc., should be of the standard used by the railroad purchasing the crane, so that repairs to the running gear can be made quickly.

The car should be built of steel and of such length that the boiler end of the crane will not extend beyond the end of the car, permitting the car to be coupled into the train without removing any parts of the crane, except the boom, which may be carried on an idler flat car. The car should also be long enough to give it riding qualities necessary for handling in ordinary freight trains. The length of a car required for this is about 24 ft. Aside from the number of wheels required to carry the weight, movement in freight trains makes it necessary that the crane have eight wheels and at least one truck should be of the standard swivel four-wheel type.

The propelling gear should be designed to propel the crane and whatever cars it will pull from four to six miles per hour. This speed is fast enough, and any surplus power of the engine should be devoted to tractive effort. The service required from the propelling gear is severe and it should be as simple as possible, of ample strength and easily replaced. Provision should be made to throw out of gear without the removal of collars or other fastenings under the car, and this feature should be handled entirely by levers or hand wheels at the side of the car or on top. The easier it is to throw the gears out, the more likelihood there is of their being thrown out when short hauls are made in a train, as is often done in switching.

The car should be provided with standard draft rigging and brakes. It is a great advantage to have an air pump and engineer's valve on the crane itself, but this feature is not absolutely essential.

The boom should not be too long except for special service, the ideal length being from 30 to 40 ft. The boom hoist should be of ample capacity and should be operated with a worm gear of such pitch as to require power to operate it in either direction.

The " A " frame should be of such design and material as to withstand shocks without cracking and at the same time should be rigid enough to keep the engine and gears in proper alinement.

As far as possible, the design of the engine and gears should be such as to permit the removal of any shaft, gear, etc., without having to remove other gears and shafts. Some cranes require the dismantling of the entire crane to replace gears that are most liable to wear out.

The reversible engine is favored by all who use it. Experiences of 15 years with hundreds of machines have proven that there are no objections to a reversible engine and its advantages in lowering a heavy load are enough to overcome any disadvantage. Needless to say the gears, shafts, sheaves and bearings should be made of the most suitable material to give the longest possible life.

There should be two drums, so that two-line buckets can be operated. One of these drums should be the main hoist for heavy loads and the other may be an auxiliary drum of lighter capacity to operate the holding line of the bucket, but both should be live drums, (power operated) because when digging in a confined space, (as in a coffer-dam) the bucket is liable to straddle a strut and must be raised in an open position to clear. An automatic tag-line or take-up device should be furnished to handle the tag-line of the bucket.

The operating levers should be in such a position as to give the engineer thè best view of what he is doing. At the same time the engineer should have ready access to the boiler compartment, so that he can fire the crane when the class of service will permit without inconvenience.

The boiler is the real limiting feature of the machine. To do work it must have energy, and the boiler is the only thing about the machine to produce energy. The boiler should be of proper size, well insulated and designed for hard service. It should be a free steamer and economy of fuel should be sacrificed if necessary to provide the maximum amount of steam. Reference to the cost of operating tables will show that the cost of fuel is a small percentage of the total cost and the results obtained are so great that extreme economy is not of importance.

Fuel and water should be carried in the greatest quantities for which space can be found.

Probably the most important feature of the locomotive crane is the manner in which the crane is fastened to the car. The up-lift on the center hold-down apparatus, or king pin, is great, and subject to shocks, and in case of breakage there is nothing to prevent the crane from overturning off the car. As this would happen without the slightest warning, this feature should be designed with absolute security in view. In buying cranes this feature should not be overlooked.

The sliding "I" beam out-riggers are to be preferred over the bracket type on the side of the car. They should be located as low as possible so as not to require much blocking. Jack-screws for the outriggers are not necessary.

An efficient device should be provided to take the load off the truck springs. This should be of such design that the crane will ride properly if this device is not removed before the crane is put into a train. The best device is, probably, a steel wedge between the arch-bar and the frame of the car.

The capacity of the crane at different radii should be plainly marked. An automatic indicator which will indicate the capacity at any position of the boom is simple and should be on every crane.

G. W. Rear, Chairman,
A. T. Mercier,
D. E. Plank,
D. A. Shope,
W. O. Eggleston,
E. T. Howson,
G. H. Stewart,
E. B. Ashby,
Committee.

APPENDIX.

The Chicago, Milwaukee & St. Paul has a number of self-propelled locomotive cranes ranging from 5 to 15 tons capacity, the latter size being most generally employed. The first cost of such a crane is from $6,500 to $7,500. The following data give the range of the cost per day:

Interest	$1.08	to	$1.37
Depreciation	1,08	to	1.80
Repairs	.26	to	1.00
Fuel	.65	to	.83
Supplies	.12	to	.15
Labor	4.40	to	5.85
Total	$7.59	to	$11.00

These figures are gathered from different localities with varying labor scales and costs of fuel and for cranes employed on different classes of work. The labor item only covers the men actually operating the crane and not the crew needed incidentally in handling material or the cost of a night watchman which would be necessary in a majority of cases.

The general storekeeper in our Milwaukee Shops uses a locomotive crane with a magnet almost exclusively for handling scrap and gives the total cost per day of operating it as $9.10. He states that he is able to accomplish an amount of work with the crane equivalent to what would require from $50 to $60 by hand labor.

Locomotive cranes are used at our two principal bridge yards which serve as distributing points for our bridge material on eastern lines and also in handling bridge material on track elevation work in Chicago and Milwaukee. At Tomah, Wis., the cost of operating a locomotive crane unloading and handling piles and bridge timber including four laborers, which are all that are required in addition to the men on the crane, is $13.45 per ten hour day. The cost of an ordinary yard crew is $14.25 per day and a locomotive crane is able to accomplish the work of two yard crews.

The following are some comparisons of the cost of handling by hand and by crane:

Timber	$0.42 per M.	$0.12 per M.
Reinforcing steel	.24 per ton	.11 per ton
Piling	.004 per ft.	.002 per ft.

Apart from the actual economy in handling material with a crane the use of this type of equipment enables loaded cars to be released in the minimum time and also assists the prompt shipment of outgoing material, avoiding congestion and enabling yard room to be used to the best advantage and the material to be piled more compactly and in better shape than by hand.

The cost of operating a 10-ton crane is given as follows: (Estimated on a basis of 300 working days per year.)

Coal, 875 lb. @ $7	$3.17
Valve oil	.08
Black oil	.01
Hard oil	.01
Crude oil	.01
Cotton waste	.01
Boiler washing	.22
General repairs	.33
Heating crane shed	.23
Interest on investment, 5 per cent	1.01
Depreciation, 7 per cent	1.41
Total	$6.49

The above does not include labor. A note contains the following statement:

A saving of 50 per cent in the cost of labor is made by using a crane for handling heavy timber, piling and other heavy materials. A saving of 50 per cent of switching service is made by using a locomotive crane.

By the use of such a crane a saving of approximately $15 per day is made over and above the expenses of upkeep, interest on investment, depreciation, etc.

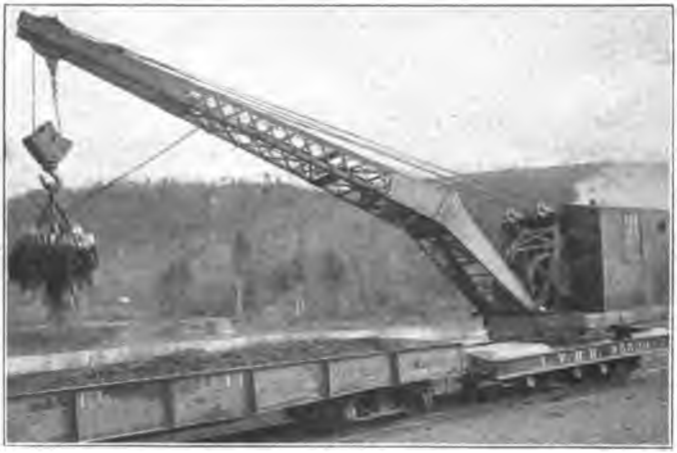
Mr. Eggleston of the Erie states that one of their ordinary cranes complete cost $13,300. Interest, depreciation, repairs, fuel and supplies cost per year, approximately $3,650, (with an average of 300 working days).

A crane with a magnet will handle as much scrap in a day as 50 laborers; as much timber, piling, etc., as 15 laborers, and as much miscellaneous bridge and building material as 10 laborers. It is invaluable in the placing of structures and structural material.

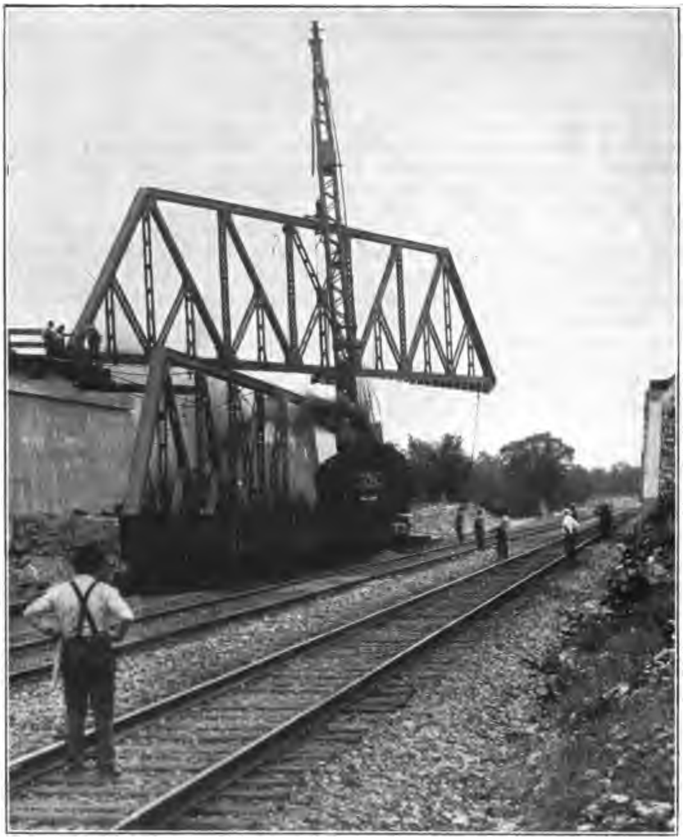
Above machine weighs 170,000 lbs.; has a pile driver attachment and can operate a drag scraper or a clam shell. Each movement independent of all others. Turning, maximum, 3 rev. per min. Propelling, on straight and level track, 300 ft. per min. Capable of handling (under same conditions) 20 loaded cars.

With No. 2 Arnott steam hammer can drive piles 34 ft. from center of track, 130 blows per min. Two tons of coal and 2,000 gals. water will operate it continuously for 10 hours. Requires two men to operate. Six men will change from boom to pile driver in 3 hours, and the reverse in about 4 hours.

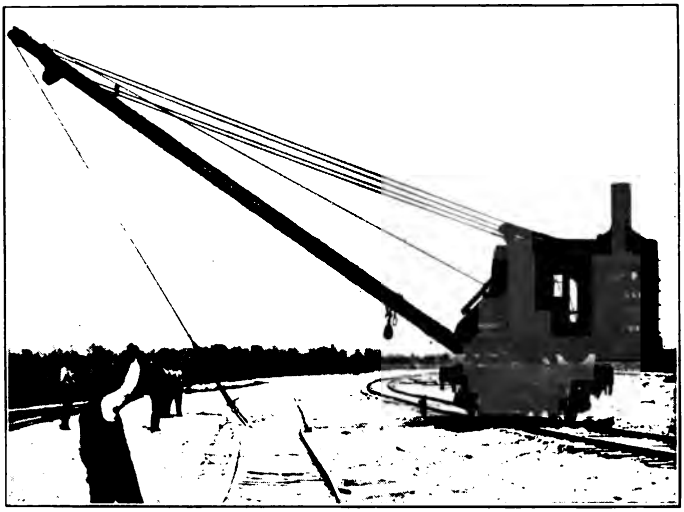
(The cuts used in this committee report were furnished by the Railway Age Gazette.)



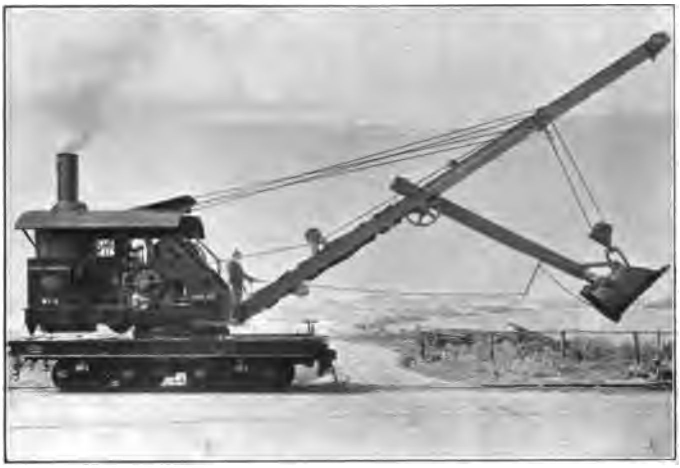
A 15-Ton Lehigh Valley Crane Mounted on an 8-Wheel Car Equipped with a Bent Boom and 43-Inch Magnet.



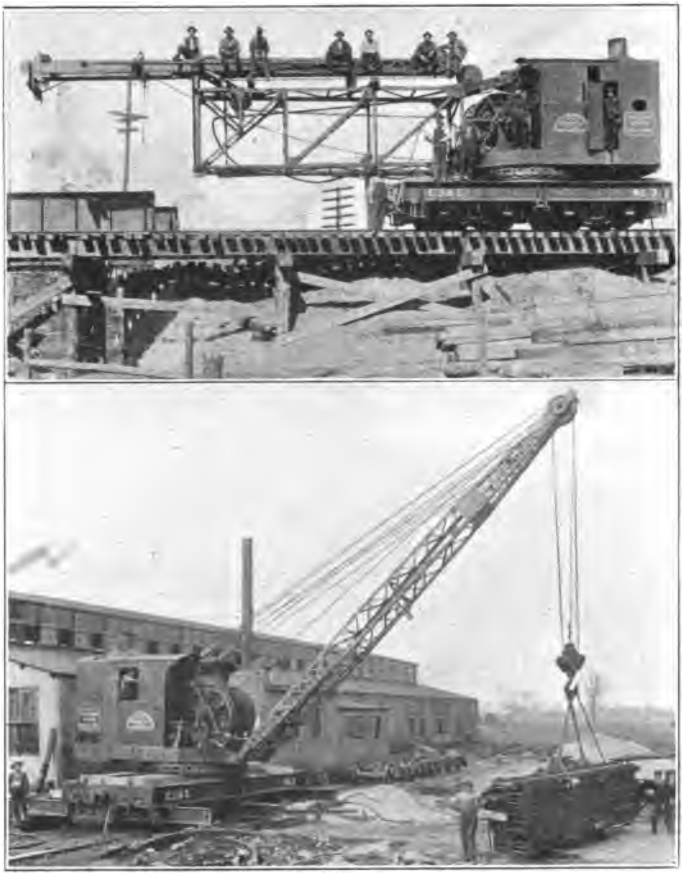
A 60-Ton Erection Crane with a 75-ft. Boom Handling a 132-ft. Highway Truss Weighing 28 Tons.



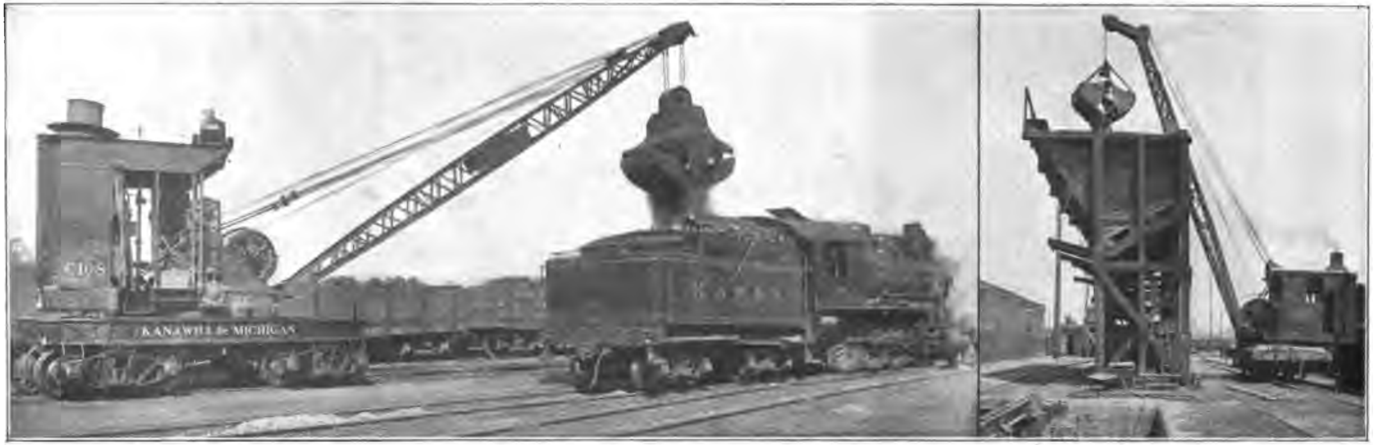
A 25-Ton Crane in the Clearing Yard of the Chicago & Western Indiana, Throwing Construction Track on New Sand Fill.



A 25-Ton Crane with Special Boom in Use as a Steam Shovel.



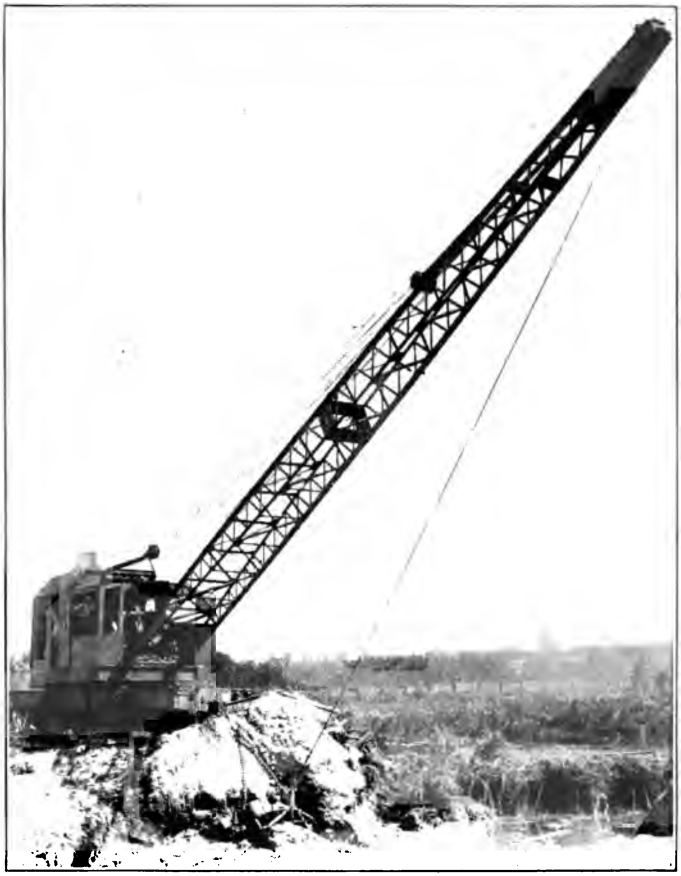
Two of the Uses to Which a Crane is Being Put by the E. J. & E. At Top Equipped with Supporting Truss for Pile Driving and at the Bottom, Lifting a Load of I-Beams with Outriggers in Place.



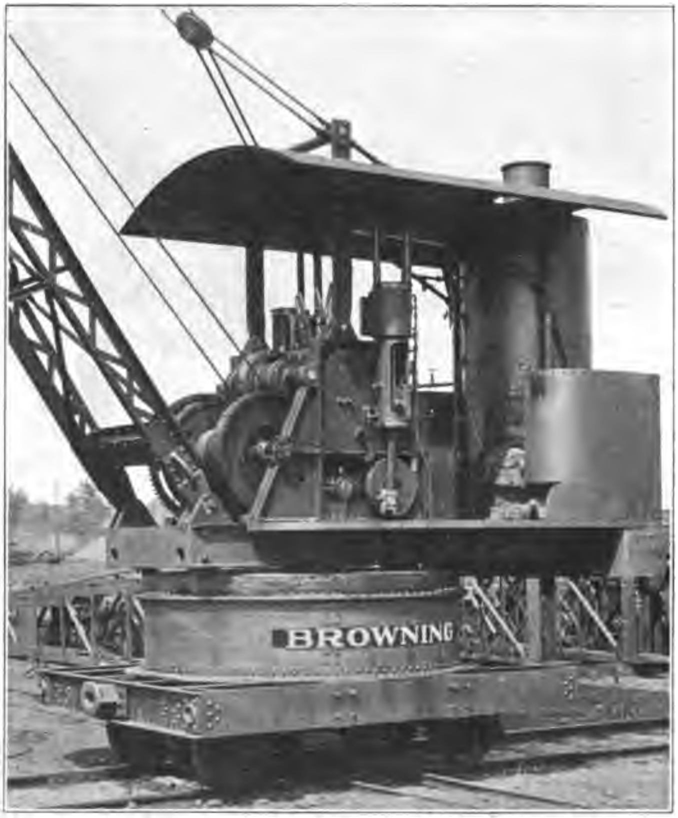
Two Methods of Coaling Locomotives with Cranes. At the Left, Direct from Cars to Tender. At the Right, Filling Small Storage Bins.

Handling 3,175 Lb. of No. 2 Wrought Iron Scrap by Hand and With a Magnet.

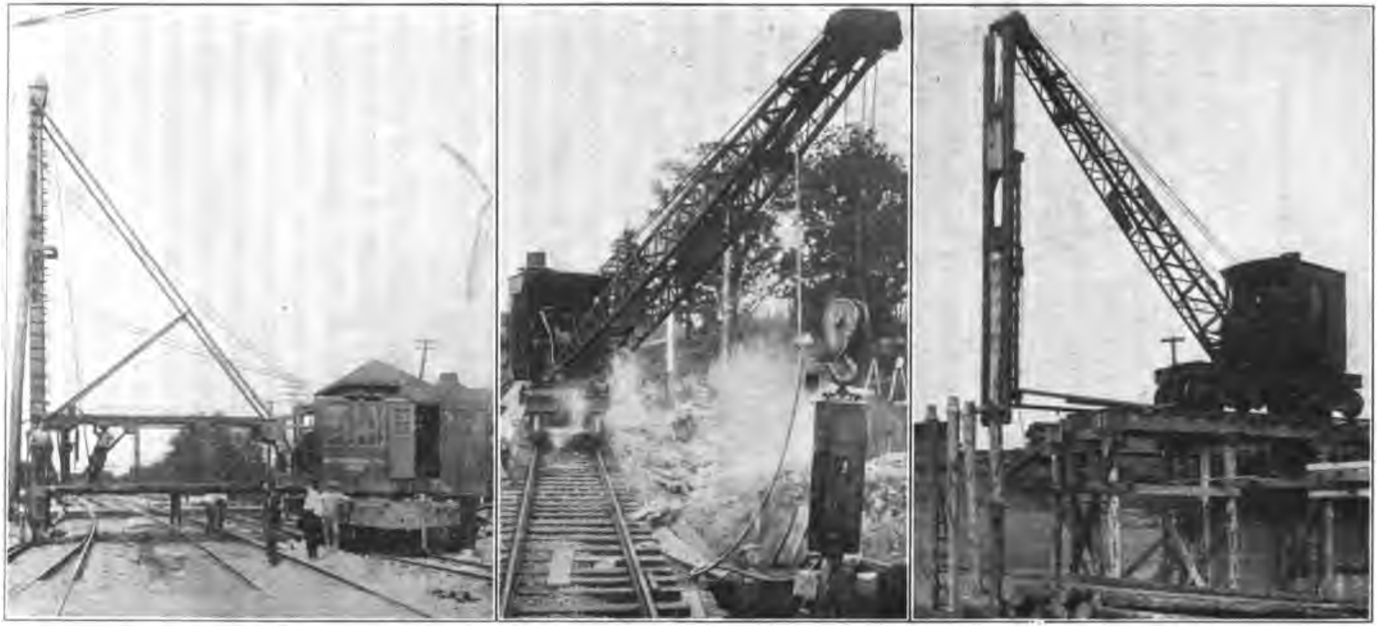
N. Y. C. & St. L. Crane on Cleveland Track Elevation Work Handling Excavated Material in a Skip.



A 35-Ton Crane with a 70-ft. Boom Equipped with a 1½-Yd. Drag Scraper Bucket.



A 15-Ton Locomotive Crane Showing Typical Arrangement of Boiler, Engine, Hoisting Drums, Operating Levers and Boom Attachment. The Mounting in this Case is Special to Allow the Machine to Rotate Over Platforms Close to the Track.



Methods of Driving Piles with a Locomotive Crane.

Truss Attachment Supporting Leaders. A Steam Hammer Suspended Without Leaders. Leaders Supported from Upper End of Boom.

DISCUSSION.

(Subject No. 1, Use of Locomotive Cranes.)

G. W. Rear:—I might say that the committee had a great deal of difficulty in condensing the report. It may be that we condensed it a little more than there was any necessity for, but we tried to make it as short as possible, so there would not be anything more in it than was really necessary. We have had considerable discussion regarding the figures shown in the table, especially the depreciation and repairs, but I feel, from long experience, that the figures are low, if anything. I had quite a few men tell me that they use a crane 300 days every year, but, frankly, I don't believe it; it is almost impossible to get a full day's work out of any crane 300 days in the year. It is doubtful whether it is possible to work one more than 200 full days in a year for 20 years. I might say that in conversation and in communication with men regarding the amount a crane was worth on general construction work, the figures they gave me varied all the way from $5 to $500 a day. We considered $40 a day as being about right. You will note at the top of one page that the fuel cost for one particular crane was 65 cts. to 83 cts. a day, and at the bottom of the same page the figure for coal was 875 lbs. at $7.00, $3.17. The amount of fuel a crane will use depends entirely on what the crane is doing. A crane propelling itself and handling heavy loads, will consume fuel pretty fast, so that it is not well to put too much dependence on the figures shown for the amount of fuel. I leave the paper open now for anyone else on the committee to add anything to it before the discussion is taken up on the floor.

The President:—Gentlemen, you have heard the paper. This subject of locomotive cranes is probably a very broad one for a large number of us, and shows how appliances have developed during the history of our association. I think that we can do missionary work here by citing a number of examples of the uses to which locomotive cranes are put. A locomotive crane is an expensive piece of equipment and it is sometimes difficult for us to convince our superior officers that it is something we ought to have. I think a discussion here might be very useful in that respect, as it will exemplify how much opportunity there is in bridge and building work to make use of locomotive cranes. Mr. Howson is a member of the committee. I would like to call on him for some comments before the discussion becomes general.

E. T. Howson:—Mr. President, it seems to me that the manufacturers, as well as railroad men, have not realized the wide range of possibilities to which a locomotive crane may be applied. The one big advantage of a locomotive crane is its versatility. Perhaps a locomotive crane may not be justified for one particular use of the bridge department, but the fact that it can also be used for other things will frequently justify its purchase. It is a handy tool that can be used for one thing today and another tomorrow. The limits of the application of a locomotive crane very largely depend on the versatility of the man in charge of it. There are hundreds of things we are doing by hand today because we have been used to doing them that way. We don't stop to think that there may be a possibility of substituting a locomotive crane for a gang of men. I was interested recently in observing the laying of rails with locomotive cranes, laying in one instance as much as 4.07 track miles of rails in a day with four cranes. While the men in this association are not particularly interested in the laying of rails, at the same time they can point out to their superior officers that a crane can be used for other things, and they can frequently get them to purchase a crane, the use of which they can then secure. My attention was called recently to the use of a locomotive crane in renewing bridge ties on a busy main line road. The crane carried new ties out onto the bridge on a flat car behind it; the rails were disconnected and a chain thrown around a number of the ties in the track; they were hoisted and thrown back on the flat car, and on the return trip the crane took new ties and dropped them in their place. Instances like that are of particular advantage on a busy line where a gang would be interrupted frequently by trains if simply putting in ties one at a time.

I believe the big value of the crane is its versatility, the fact that it can be applied to a large variety of work. The men on the different divisions can apply a crane to many jobs they don't think of today, if they get one and develop its uses. That has been the experience of the roads that have gone into the use of cranes the farthest. Some roads have one or two cranes and consider that they are well supplied. The Southern Pacific has 30 or 35 cranes. I believe the Lehigh Valley, with only

1,100 or 1,200 miles, has 30 cranes and they keep them all busy.

The President:—There must be a number of others who are directly interested in the use of locomotive cranes. I would like to hear from members in different parts of the country to learn how widespread and how diversified are the uses of cranes. I have not seen very much literature on the use of locomotive cranes in the south.

C. W. Wright:—One very good use of a locomotive crane is found in arranging for the cheap storage of coal. A pit may be constructed under the track, with a circular track around it, and coal can be dumped into this pit and piled by means of a crane running on the circular track. It is possible in this way to arrange for the storage for at least 50,000 tons of coal at a time at a cost of from $1,500 to $2,000. The crane is then used to reload the coal for shipment to points where needed.

R. C. Sattley:—I would like to ask the cost?

C. W. Wright:—It has only been running a short time and I could not give the figures.

J. S. Robinson:—I would like to ask if there is any difference in the cost of unloading that coal from the cars and afterwards loading it up again into cars from this pit?

C. W. Wright:—I imagine it would cost more to load it than it does to unload it. It is simply dumped into this pit and it does not require any switching, but I imagine it would cost more to get the coal out of the bank into the car.

W. E. Alexander:—I am interested in locomotive cranes. We have one 75-ton locomotive crane. I do not find that it would be economy for us to use that for so many varied things as have been spoken of here. The mechanical department handles that crane. It is a wrecking crane and it goes to wrecks whenever one occurs. It is the only heavy crane on the road and we only use it for heavy work. We use it in the yard where it belongs, for handling scrap and for loading and unloading heavy materials and keep it there except when it is used for wrecking or for some important work. If we need it to set something heavy out on the line we return it to its headquarters as soon as we are through with it and do not keep it out only on short jobs. It seems to me to be economy to have something else to do some of the work spoken of.

We have a rail loader which is a very useful machine. It goes along on the track and loads an entire train of cars. It is the most economical device to load rails that we can get. We have also a ditcher which is used for a great many things on which locomotive cranes might be employed. These machines belong to the maintenance department.

We have taken the locomotive crane out to remove a turn table where we wanted a longer table in its place. The crane would not handle such a table at its full radius (we took out a 60-ft. table and put in a 65-ft.); but by blocking out nearer the centre, we could do it all right. After we did that we turned the locomotive crane right back to the shop where we thought it belonged and we did not keep it out to unload the other table. We took that one out by hand, which was much cheaper than to take the crane away up the road to do it; it depends a great deal on the kind of work we have to do and how we are situated. As some of the men have said here, some roads have a number of cranes. That is all very well, but we have only one and we have to conserve it for the more important uses.

The President:—The last speaker had reference to large capacity cranes, but what this paper has in mind especially is a smaller crane that can be put to a great many diversified uses, a crane from 15 to 25 tons capacity, possibly. I am sure there must be a number of members here who have had experience with that kind of a crane.

R. H. Reid:—We have on the New York Central several smaller capacity locomotive cranes, ranging from 3 to 15 tons, that are used principally in the engineering department. We use those cranes to set iron and concrete pipes, to load timber and to handle various kinds of bridge material; and we have used them at various times in erecting bridges. Last fall we erected a 160-ft. riveted through truss, span complete,—except the four end posts,—with a locomotive crane. The four end posts were too heavy for the crane and we had to get one of our steam wreckers to handle them, but all the rest of the work was done with locomotive cranes. We have erected other spans of various sizes with locomotive cranes and the total cost of erecting is far below the old cost of steel erection.

In some cases we use concrete pipe 5 ft. by 5½ ft. in diameter and weighing about 7,000 lb. to a section. They are necessarily difficult to handle. One cannot roll them around very much and he cannot drop them. We generally handle those with a locomotive crane. With a long boom one can place them out a considerable distance. We contemplate the installation of a 5 ft. by 5½ ft. concrete pipe culvert 108 ft. long with a locomotive crane. It requires a pretty long boom to reach out 54 ft. from the center of the track and handle a 7,000-lb. load. If we had to handle those pipes by hand, it would cost 4 or 5 times as much as with a crane.

Locomotive cranes are economical for switching as they save the cost of a work train and crew. A locomotive crane costs us about $4.50 or $5 a day complete; a work train will cost at least $25 a day. For our heavy work we use a wrecking train. Where we are placing heavy bridge girders, of course, we have to have a heavy capacity crane but the light cranes are very convenient. We have a pile driver that I have equipped several times with a temporary boom for bridge erection. Of course a pile driver with a boom on it won't erect steel very high, but we have put in several thousand tons with the driver on bridges below the track, and in that way we kept the total cost of erection, riveting and all, down to within $3 or $4 a ton.

The President:—We have several men here, who, I believe use locomotive cranes quite extensively. It seems to me the versatility of the locomotive crane is illustrated by the demand that frequently comes from other departments. I know that on our own road the demand for the loan of a locomotive crane frequently comes from the operating department. We have a hard time to keep it on our own work. The operating department will be called upon to receive a heavy shipment at some point where there are no mechanical appliances and we get a prompt call for a locomotive crane to be sent to that point. That illustrates to me how useful a tool it is—when everybody wants it. I think there ought to be some more people here who could give us a discussion of the subject under consideration. This committee has outlined a very able summary of the salient points to be considered in obtaining a crane, and I think that part of the report ought to be discussed more. I would like to hear some discussion of that part of it.

J. S. Robinson:—We have a locomotive crane with a 35-ft. boom, which we use at one of our coaling stations where we store coal (and we had stored at one time something over 100,000 tons). We have unloaded as high as 20-60,000 to 80,000 lb. cars a day at a cost as low as 6 cts. a ton. We have a disposal yard next to this coal storage yard where we take the refuse from our yards, from the streets, freight houses, etc. We tried to use this crane with a clam-shell to unload those cars of rubbish, but we found that was not so successful. We would average 6 and 8 cars a day, unloading and disposing of this rubbish. I would like to know if any gentleman here has had any experience of that kind and about what it costs to unload rubbish as well as to unload coal?

W. O. Eggleston:—In February, 1915, the Erie road had 33 locomotive cranes of various designs. We use them for excavating, switching, handling all kinds of material around shops and on the road and in fact for almost everything imaginable. We have a special design of a locomotive crane, a partial description of which appears near the end of the report, that is particularly useful in erecting and dismantling bridges. It has a 70 ft. boom and all ordinary bridge work can be handled with it. Such a machine is equal to 100 men in a scrap yard. In continuous operation it uses 1½ tons of coal and 1,000 gal. of water per day. Two men, an engineer and a fireman operate it.

In building over 200 miles of second track we had quite a number of overhead highway bridges to erect and I was fortunate enough to get hold of that machine to do the work. In one case we handled a 70-ft. deck girder at a radius of 20 ft. very nicely. We used it in handling the floor system, and in fact all the work encountered in overhead highway construction and I consider that we effected a saving of more than 50 per cent over any other method that we could have adopted. As stated in the report, we use this machine for driving piles also.

J. S. Robinson:—Can Mr. Eggleston give us the cost per foot of driving a pile in that manner?

W. O. Eggleston:—I have nothing on the cost of driving piles. I have heard the foremen say that they could drive 15 or 20 piles per day, but I cannot judge anything by that.

The President:—Mention has been made in the paper of the use of locomotive cranes in yards. We surely have a number of bridge men here who have had experience with the use of a locomotive crane in that manner.

A. S. Markley:—In looking over the list, I note one item amounting to $6 per day for labor. Of course, I presume that applies to yard service. For main track service the state laws of Indiana require a full train crew, and in such cases it would be necessary to add the cost of a train crew. Labor organizations are endeavoring to have a schedule adopted to prohibit these machines being operated on the main track in all states without a full train crew. I understand the law in Indiana is very severe. We have never tested it; we keep clear of it.

There is no limit to the use of such cranes. They are economical, even with the cost of a train crew added under certain conditions, by the saving of at least 25 to 75 per·cent of labor. We have an old pile driver which we converted into a derrick-car which is useful for loading and handling all kinds of material. It is capable of lifting about 10 tons.

The President:—The derrick-car would hardly come under this discussion; it would be a separate item. What this applies to is really a locomotive crane, designed as such.

Mr. A. S. Markley:—I don't quite understand your point. This does the same work as a locomotive crane.

G. W. Rear:—No,—a locomotive crane is a derrick that will propel itself.

A. S. Markley:—This is a self-propelling derrick that I am talking about. It has all the features except the turn-table. We also have a regular locomotive crane and two ditching machines. They are used in excavating for wells and a great variety of work. Timber can be handled at 25 to 75 per cent less than by hand.

C. R. Knowles:—I don't know much about a locomotive crane, but I notice that they are being used for transferring heavy logs and steel at wharves.

E. T. Howson:—The comment of Mr. Reid about the use of locomotive cranes for switching service called to my mind a use I saw three or four years ago where locomotive cranes were employed in gravel pits, where only a limited amount of concrete gravel was required, not sufficient to justify the installation of a steam shovel and work trains. A locomotive crane was placed on one track and the cars on the other. The crane ran beside these cars, filling them in turn, and the local freight did the switching. This made a very economical arrangement for loading about 15 cars of gravel a day.

G. W. Rear:—In preparing this report we got it up from the point of view of a man who had been using cranes all the time and to whom their use was so obvious that we cut out many things we had in mind putting in the paper, because it looked as if it was carrying coals to Newcastle to tell them what to do.

We have cranes that do everything. Our cranes start the men to work in the morning by blowing a whistle; we have to watch to keep our men from standing around waiting for a crane to do the work they could do.

Taking up the points that have been brought up in the discussion, Mr. Alexander speaks of using a wrecking crane. A wrecking crane is not a locomotive crane at all. It will not propel itself. We had a chance to buy a crane of light capacity lately and we took it up with the manufacturer to see if he could make a locomotive crane out of it. He said, No, that if we did, the hoisting gear would be so slow that we would be tired of it from the start. Wrecking cranes are eliminated from the use to which we want to put locomotive cranes, and in counting the number of cranes, the Southern Pacific has eliminated all wrecking cranes.

We took up the cost of loading coal in and out of cars. You will generally find that it will cost more to unload the cars with a crane than to load them up again, on account of cleaning out the corners. We found that where you could dump the coal out of the car and then handle the coal you could move it for very much less money than you could by digging it out of the car itself on account of having to get the coal out of the corners.

The only way one can handle rubbish is to dump the stuff out of the cars before handling it with the bucket. The bucket will not get hold of old tin cans and all such debris in a car. If you use a bucket that will dig, it will tear up the floor of the car, and if you get a bucket that won't tear up the floor of the car, it won't dig. If it is possible to dump the rubbish out and then dig it from the ground, you can handle it in good shape. This also avoids cleaning up the track after each car has been dumped as one can leave a considerable amount of stuff on the track.

Speaking about bridge erection with a crane—we have found in a good many cases with short trestles, of 100 ft. or so, that we could put the structure up before we could set up any other kind of apparatus to do the work with. We could go to the work in the morning and have the structure all up by the next night, and it would probably have taken that long to rig up apparatus to do the work with.

One gentleman asked if anybody could say what the cost of driving piles was with a crane. I would like to ask if anybody knows what the cost of driving piles is with any rig? I don't believe anyone here can say that it costs so much a foot to drive piles with any kind of driver. One never drives them under exactly the same conditions, and it is doubtful if anybody could say what it is worth to drive them with any kind of device. Can you, Mr. Robinson?

J. S. Robinson:—No sir, one can't do it.

G. W. Rear:—With reference to train crews on cranes. The California law now requires one to have an engineer, a conductor and one brakeman on each self-propelled machine capable of transporting itself and one car on all lines operating more than 4 trains in each direction per day. It was originally intended that one could work them within yard limits, but the law reads that you must not work them more than ½ a mile from any siding or station without having a train crew as I have mentioned. We are getting around that at the present time by putting in a siding at each place where we are going to work a crane for any length of time and having the crane delivered at the siding by a regular train or with a train crew if necessary. It is hard to say whether future legislation will put another crimp in this or not. As to handling freight on wharves, there is hardly any place with an up-to-date method of handling freight on wharves that does not use a locomotive crane, but we considered that out of our jurisdiction. As to loading ballast in ballast pits—that is the greatest enemy we have. Half the time half of our cranes are loading ballast in ballast pits, and when one starts loading ballast, it is goodbye for that crane. We never see it any more. I might also say that whenever anybody gets one of our cranes in his possession it is like pulling teeth to get it away from him again. I never saw a man yet but if I asked him if he could release the crane, would say that he could not. We have to be arbitrary at times and take them, because no one will ever volunteer to give one up after he has the use of it.

The uses of these cranes are obvious to a man who will think of the subject at all. Their particular advantage is that you have a hoisting apparatus that you can take anywhere you want it, and the minute it is there, if you have the right kind of a crane, it is at work. We have some lines where logs fall off the cars. We wait until the right of way is covered with them and then run a locomotive crane out and pick them up. It is the same way with large rocks—after a while we go out and gather them all up; there is an endless variety of uses that a crane can be put to.

SUBJECT NO. 2.

PILE AND TIMBER TRESTLE BRIDGES.

REPORT OF COMMITTEE.

After consideration by the committee it was decided to send letters of inquiry to various railroads having membership in the Association and on May 18, 1915, the following letter was sent out by the chairman:

"As chairman of committee No. 2 of the American Railway Bridge and Building Association, the undersigned finds it necessary to secure information with reference to the present practice of the various railroads in the construction and maintenance of pile and timber trestle bridges, and will be obliged if you will furnish him for the use of the committee blue prints of your standard trestles stating if there is more than one standard and under what conditions the various types are used.

"The assignment to the committee for investigation reads as follows:

"Pile and timber trestle bridges—Conditions under which they should be repaired, reinforced, renewed or replaced. The effects of soil and climate. The effects of animal and vegetable life. The application of paints and preservatives. When and in what manner are repairs to be made. The reinforcing of bents and stringers. When and in what manner are extensive renewals to be made. Under what conditions should a trestle be replaced with a similar structure. Under what conditions should it be replaced with permanent work.

"Please also furnish estimated costs for the various types and various heights.

"Also furnish full information for your road as to the length of life, the methods of inspection, the manner of carrying out maintenance repairs and renewals, and any other information of interest or importance in this connection.

"Please also let me have full advice as to the use of treated timber, ballasted decks, fireproof trestles, and any other information that may be available along these lines.

"It is hoped that each railroad official to whom this letter is addressed will coöperate with the committee in giving us the fullest possible information with reference to present practice of the road represented."

The replies to this letter were not as numerous as might have been desired, but sufficient replies were received to formulate in sufficient detail the present practices of the various roads.

The information as to design of trestles received by the committee indicates that the ideas of the various engineers cover a wide range as to detail, while, at the same time they necessarily follow along the same general lines. The sizes of standard parts and the amount of timber used for carrying the same loads under apparently the same conditions appear to be different and a large part of the difference is apparently due to the personal equations of those responsible for the construction and maintenance of the trestles as well as the amount of experience such men have had and also to a certain extent to the financial conditions of the various roads. For example: Standard pile bents vary from 4 to 6 piles under approximately the same conditions. Standard stringers vary from 3-ply 8 in. by 16 in. to 4-ply 10 in. by 18 in. for carrying approximately the same loads on spans of nearly the same length. While, of course, it will never be possible to eliminate entirely the effect of personal equation, a more uniform standard of practice would appear possible.

OPEN DECK TRESTLES.

Ties.

A width of 8 in. appears to be almost universal for bridge ties, the spaces between them varying from 4 to 6 in., placing the ties from 12 to 14 in. center to center. The depth of ties varies from 6 in. to 11 in., the great majority of roads reporting the use of a tie 8 in. deep which the committee feels is the proper depth to use. A great deal of labor expended in the past by all roads and at the present time by some roads for dapping ties to fit down over the stringers can be avoided entirely, either by purchasing the ties surfaced to the exact height (7-¾ in. in the case of 8 in. ties), or by gaining them in the field to exact depth. The first method is recommended. In many sections of the country, it will be found that the surfacing of the ties to exact depth at the mill will not increase the cost.

Lengths of 9 ft. and 10 ft. have been reported for bridge ties but the committee feels that a length of 9 ft. is sufficient except in those cases where a very heavy chord is used for long panels or for unusually heavy loads. In such cases increasing the length of the ties to 10 ft. may be necessary to secure the proper bearing over all of the stringers.

The lateral stability formerly provided by the shoulders of dapped ties fitting down over the stringers is now secured in some cases by the use of lag screws or drift bolts fastening every fourth tie to the stringers; and in some cases by driving dowel pins into bored holes in the under surfaces of each end of every fourth tie, the ends of the dowels projecting downward into the packing space between the bridge stringers. The latter method is of advantage in eliminating the damage to the stringers caused by the insertion of lag screws which latter frequently start decay on the tops of the stringers.

The committee feels that the track rails should be held securely in place on bridges by the use of tie plates having a length equal to the full width of the face of the tie, that is,—8 in. wide, but it does not recommend the use of tie plates with claws piercing into the fibre of the tie as such plates are found to induce more rapid decay of the tie. This does not necessarily require the use of flat bottom plates as slight corrugations on the bottoms of tie plates will provide sufficient lateral holding power without breaking the fiber of the wood.

Guard Timbers.

Regardless of all that has been said and written with reference to the dapped guard timber, no more effective means of holding the ties in place has yet been perfected. The committee feels that the practice that now prevails to some extent, i. e., the laying of a flat timber on top of the ties near their ends and fastening that timber to each end of each tie by a lag screw will not prevent the ties from bunching in case of derailment, as effectively as the old dapped guard timber. While the lag screw will undoubtedly hold the tie in place under ordinary conditions, a derailment can be expected to split the ties or the guard timbers in such a way as to permit the ties to bunch.

The committee feels that the only effective method of preventing the ties from bunching is to provide between them struts having shoulders at the ends, bearing against the sides of the ties. Such struts made of malleable iron castings have been devised and are being used to a slight extent experimentally. Their advantage rests in the elimination of the labor of framing guard timbers, a very expensive procedure. If their experimental use proves successful, they should be used in preference to a flat timber lag-screwed to the ties.

Inside Guard Rails.

The committee feels that inside guard rails weighing about 60 lb. per yard spiked to every tie and fully and carefully bolted to eliminate any offsets at the joints, should be laid entirely across every trestle ultimately, and that, as a move in that direction, roads not using such guard rails, commence their installations on high bridges, long bridges and all bridges on curves, the exact length and height to depend upon local conditions and the length of time over which the road desires to extend the expense of this improvement. Such guard rails should extend approximately 30 ft. beyond each end of each bridge and there come to a point either by the use of a casting inclosing the ends of the rails or by the use of an old frog point.

Bridge Stringers.

Bridge stringers in use on various roads vary from 6 in. to 12 in. in width and from 15 in. to 20 in. in depth. The most universal size appears to be 8 in. x 16 in. of which 3-ply stringers are used most universally although 4-ply stringers are extensively used on the longer panels and under the heavier engines. The panel lengths run from 12 ft. to 16 ft., the heavier stringers being used on the longer panels.

The exact panel lengths and dimensions of stringers to be used depend to a large extent upon the availability of pile and stringer material. If piles are difficult to secure and long stringers can be secured readily these conditions indicate the desirability of using panels up to 16 ft. entailing the use of more and heavier stringers and less bents, while if the larger sizes of sawed timbers are difficult and expensive to secure, and piles can be secured easily these conditions indicate the desirability of using shorter panels involving the use of less stringers and smaller sizes and more piles.

No roads have reported the use of short-length stringers, breaking joints over every bent as all roads report the use of stringers twice as long as the panel length, alternate stringers breaking joints at the alternate bents. Stringers are usually framed to exact depth at the bearings. In the past and to some extent at the present time, stringers have been framed at the packing points to exact dimensions, but the best practice indicates the desirability of using stringers just as they come from the mills as far as width is concerned thereby eliminating the extra labor and weakening of the stringer caused by cutting into the side to preserve exact dimensions. While the practice of framing the sides of stringers so the chord would pack to exact dimensions was excusable in the past when dapped ties were used, thereby making possible a fit of the dapped tie over the chord, the use of the undapped tie renders the exact width of the chord immaterial and the side framing of stringers should be dispensed with.

On account of the extra cost that would be incurred in the extra handling of such heavy timbers as bridge stringers, it is not considered desirable to require that they be surfaced at the mills but that they be used in the slightly variable widths furnished. The various stringers composing a chord should be packed with spaces not less than ¾ in. clear between them, two chord bolts being put through each end of each stringer, making four chord bolts over each bent.

Although in the past when narrow chords were used, it was quite customary to place the chords outside the rails to give greater stability by the greater width of bearing on the caps, the increase in the width of the chords caused by more and heavier stringers has rendered this generally unnecessary and on account of the necessity of distributing the load on the rail equally among the various stringers in each chord with as little danger of over-straining or breaking the tie as possible, it seems desirable to place the center of the chord directly under the center of the rail.

To keep the caps and stringers from changing their relative locations at the bearings, many types of anchors are used, consisting of dapped corbels, packing blocks or boxes, drift bolts, through bolts, straps, etc. The tendency of the best practice today is toward the elimination of corbels, packing blocks or boxes and drift bolts, although drift bolts are still extensively used. Their use results in serious damage to stringers as it frequently happens that after they have been drifted down, they must be withdrawn in connection with relining or other work on the bridge and the pulling of such drift bolts is frequently a difficult operation, sometimes necessitating chopping into the stringers to get hold of the drift bolts. The same result can be secured and the bolts made more accessible by boring entirely through the stringer and cap and placing at least one through bolt, not less than ⅞ in., entirely through the stringer and cap at each bearing. Although it is desirable for stiffness to have nuts and washers on the lower ends of these bolts, this is not absolutely necessary as the lower ends extending under the caps provide means of starting them out in case of work on the bridge.

Caps.

The caps in use vary from 12 in. by 12 in. to 14 in. by 14 in., a few instances being reported of the use of caps composed of several timbers framed over the tops of the piles. The framing of the tops of piles to fit into two or more timbers forming a cap appears unnecessary and has almost disappeared. For ordinary conditions a 12 in. by 14 in. cap 14 ft. long should be sufficient, the 12 in. dimension being vertical and giving a 14 in. width of bearing. Great care should be taken that the piles are sawed perfectly true under the caps so as to offer full bearing on each pile. There should be one or more drift bolts through the cap into each pile.

Piles.

Replies indicate the use of 4 to 6 piles per bent, some roads using 6 piles on very low bridges, while other roads use 4 piles on very high bridges. Most roads report the use of a 5-pile bent. If good, large piles can be secured, there is no question but that 4 piles, well driven, will support any load that can be brought on the bent for moderate heights and that for additional lateral stiffness on curves and high bridges over 20 ft., 6-pile bents should be used, the two additional piles being placed on the outside and battered for lateral stability. The designs of 5-pile bents submitted almost invariably show the middle pile entirely relieved from load, and the 4 outer piles of such bents would usually carry the same load per pile if the middle pile were omitted.

A great advantage in the use of a 4-pile bent, occurs especially in redriving old trestles when the use of a 5-pile bent would require shifting the chord out of place during the driving of two of the piles under the stringers while the 4-pile bent can be so arranged that for ordinary conditions the four piles can be driven without interfering with the old chord. This advantage, of course, will not obtain where the largest 4-ply chords are in use on bridges to be redriven, the shifting of the chords in such cases being necessary in any event.

Frame Bents.

The same conditions as to the number of posts apply to frame bents as to pile bents, the added requirement being the necessity for a firm, unyielding foundation under the frame bent. This foundation is sometimes provided, especially in new construction, by concrete pedestals, where rock is close to the surface. For high bents footing piles in sufficient number are frequently driven, the local conditions controlling the number and character of such piles.

Some roads make a practice of cutting off old pile bents and placing frame bents on top of the old pile stubs. While at first glance such construction gives a very rigid support there are many undesirable features. When frame bents are placed on top of old piles cut off at low water line and having a considerable unsupported length in the water there is danger of them buckling out of line. Also the sills and lower ends of the legs of such bents and also of frame bents having the sills at or just below the ground line decay very rapidly and introduce an element of weakness into the bridge. Reports have been received indicating that all the pile bents of long. low bridges are frequently cut off when ready for renewal and replaced by frame bents. In such cases very adequate longitudinal bracing should be placed at proper intervals to prevent the bridge from collapsing longitudinally. If floods or other conditions prevent the placing of such longitudinal bracing, a considerable percentage of all the bents should be renewed as pile bents instead of being cut off and renewed as frame bents. A case has been reported of a 67-panel frame trestle 12 ft. high, resting on old pile stubs and having no longitudinal bracing whatever because of interference such bracing would offer to the flow of water and the passing of drift, collapsing longitudinally under a ballast train stopped by a bursted hose causing an emergency setting of the air brakes.

The general practice seems to favor the use of 3 in. x 10 in. braces. On some roads the braces are bolted to the posts or piles, while other roads continue to use boat spikes. The committee recommends that the use of boat spikes for such purposes be discontinued. and that not less than 3 in. x 10 in. bracing be through bolted by ¾ in. or ⅞ in. bolts to the caps and piles or posts, double sash bracing and two sets of " X " bracing being used in bents over 24 ft. high.

All roads report the use of two or more lines of longitudinal struts or ties, varying in sizes, on all frame or pile bents over 24 ft. in height; these being placed above and resting on the sash bracing, and being bolted or spiked to the posts or piles. The best practice would seem to be that of cutting longitudinals to fit between the posts or piles. obtaining continuity by the use of blocks or splices at the posts or piles, securely bolted to them.

BALLAST DECK TRESTLES.

The committee feels that the use of ballast deck trestles of treated timber should be given further consideration. as it is believed that very considerable economies can be shown by the use of such structures. The best information indicates that the cost of construction of a ballast deck trestle of creosoted material will be approximately 50 per cent greater than the cost of a similar open deck untreated trestle of standard construction. For ballast deck trestles standard track ties may be used. There should be at least 6 in. of ballast, preferably sandy gravel. between the bottom of tie and the floor of the trestle. The floor of the trestle should be composed of 4 in. plank 13 or 14 ft. long. To prevent water from getting into the floor and timbers below, the floor should be covered with a built-up roofing of about 4-ply felt and pitch. The sandy gravel ballast will make a sufficient bond with this roofing so that other covering over the pitch will be unnecessary. Drainage should be provided by leaving open spaces between the floor of the trestle and the guard timbers at the edges of the ballast by raising the guard timbers 2 in. off the floor and providing a washer at each point, approximately 4 ft. apart, where the guard timbers are bolted through the floor.

The committee recommend that the stringers on ballast deck trestles be not sawed off at the ends but that they be lapped. the length of stringer to be one foot longer than twice the panel length to provide practically a full bearing at each end of each stringer. The number and size of stringers will, of course, depend upon the length of the panel and the loading to be carried, as mentioned above for the open deck trestle. It is thought, however, that the equivalent of 4-ply 8 in. by 16 in. stringers under each rail for 14 ft. panels and 5-ply 8 in. by 16 in. stringers for 16 ft. panels will give sufficient carrying strength for any loads now operating. There appears to be no reason for the use of outer guard timbers on ballast deck trestles as the ballast will prevent the ties from bunching on the trestles as well as that service is performed on solid ground. Inner guard rails should be furnished however, as on open trestle bridges.

FIRE PROTECTION.

The methods of fireproofing timber trestles are well set forth in the report presented at the 1911 convention. The committee feels, however, that the use of a gravel covering for the fire protection of open desk trestles should be discouraged except in a dry country, as in a wet country the gravel will hold moisture and promote decay. The most popular and apparently the most efficient method of protecting timber trestles against fire is by the use of galvanized iron over the caps and stringers. Galvanized iron should not be less than No. 20 gage, and preferably some of the brands of so-called "pure iron" should be used, as the increased cost will be more than made up by the greater life and the less frequent disturbance of the trestle for renewals. Information indicates that the length of life of untreated timbers will be very materially increased by so protecting them with galvanized iron.

As an additional precaution, water barrels should be supplied and kept full of water. For bridges up to 30 ft. long, one wooden barrel should be placed in the ground at the end of the bridge; for bridges over 50 ft. and up to 150 ft. long, one barrel should be placed at each end of the bridge; for bridges larger than 150 ft., intermediate barrels should be placed on extended ties or floor planks at intervals not exceeding 150 ft.

While it would appear that creosoted timber would catch fire more readily and burn more fiercely than untreated timber, information indicates that this hazard rapidly passes off as the timber becomes dry, and when dry, creosoted timber is somewhat harder to ignite than untreated timber. Additional security is also effected owing to the fact that creosoted timber is free from the decayed wood which causes most of the fires in untreated timber.

MAINTENANCE CONDITIONS.

The letters quoted in the following pages indicate as well as can be pointed out the conditions under which maintenance, repairs and renewals are carried out. In general, the rule of reason prevails. If one or a few timbers in a comparatively new bridge develop defects or indicate that they are decayed long before the remainder of the bridge, it is obviously proper to renew those members in order that the structure may be of uniform strength.

As the bridge becomes older other and more timbers will require renewal, and the point will soon be reached where individual judgment must decide whether such timbers will be renewed with new timber or with good second-hand timber having a life equal to that remaining in the structure, or whether, on account of the approaching necessity for the entire renewal of the bridge, the decayed timbers will be left in place and additional timbers placed alongside as helpers. No set rule can be established as the variable length of life of different timbers of apparently the same lasting qualities renders necessary the exercise of the greatest skill and individual judgment, which can only be obtained after long experience. The renewal of individual guard timbers and ties presents little difficulty. In order to maintain a uniform appearance, it seems desirable when renewing individual ties to use similar second-hand ties in place of the old ties, many such second-hand ties being released from other bridges on which all ties are being renewed.

Renewal of individual stringers, especially inside stringers in packed chords, offers considerable difficulty, and where there is a sufficient length of tie projecting beyond the outer stringer, which will be the case if the chord is centered under the rail, it will invariably be desirable to leave the weak stringer in place and transfer its duty to a second-hand stringer of equal size placed as a helper outside the chord. The same conditions will obtain in the renewal and repair of frame and pile bents. In the patching of bents, however, care should be taken that not more than two posts or piles in a bent are spliced or posted. The practice of posting or splicing all or nearly all the posts or piles of a bent has resulted disastrously in a number of instances as such practice practically eliminates the longitudinal stability at or near the ground line.

The effects of soil and climate are very marked. In high, dry country, timber not in contact with the soil will last much longer than anywhere else, but even in high, dry country timber near the ground line in contact with the soil is subject to extreme alternate conditions of wetness and dryness causing rapid decay. On account of such extreme changes, there is usually sufficient moisture below the ground line in impervious soil to preserve the timber for a long time and the most rapid decay takes place immediately at the ground line. In pervious, sandy soils the dry atmosphere rapidly removes the moisture from the outer layers of sand and transfers the point of most rapid decay into the ground. Under the latter conditions piles and timbers that appear sound at the ground line will frequently fail somewhat below.

In low, wet country the most rapid decay usually takes place at or slightly above or below the ground line. The constant moisture below the ground line preserves the timber almost indefinitely in impervious soil, while in pervious sandy soils the point of most rapid decay is transferred slightly below the ground line. In low, wet country the timbers above the ground line not in contact with the soil are constantly changing from a wet to a dry condition and under such conditions show rapid decay.

Except in a few isolated cases that have been reported of woodchucks and other animals gnawing timber supports under bridges, the marine borer is the only animal that has been reported as damaging timber. Present information indicates that marine borers can only be effectively protected against by mechanically encasing timber piles or by thoroughly creosoting them. If these alternatives can not be resorted to concrete piles should be used as there is no justification for temporizing with the situation by the use of untreated timber piles.

In the fall of each year when consideration is given to the work that will be required during the following year, decision should be reached as to whether a structure will be replaced in kind or with a more permanent structure. The first consideration is the line and grade, the permanency of which should be assured before changing from a timber to a more permanent type of structure, as expenditures made for permanent structures to replace timber structures on lines that will be altered in the future are thrown away. In case there is any possibility that the line or grade will be changed materially in future, temporary structures should be maintained in kind. Where the permanency of line and grade is assured, as is the case on many miles of low-grade lines of good alignment, pile and timber trestle bridges should be renewed by permanent structures as fast as conditions permit.

The conditions that determine the construction of permanent structures are economy and policy. The economy of such a change can be arrived at by determining, after a careful engineering study the least expensive structure, annual charges being taken into consideration, that can be constructed to carry the track over the space in question. In some cases this will consist of a solid fill, in others of a solid fill over a culvert or other opening of the necessary size, while in still other cases bridges of concrete or steel may be required to provide the necessary opening. The ultimate economy can be arrived at by comparing the annual charge for interest and maintenance for the pile or frame trestle bridge, the renewal of which is to be considered, with similar charges for the permanent structure that is required. In case the permanent structure shows a decrease in the annual charges, the work should, of course, be carried out at such time as funds are available, and in many cases where funds are not available immediately but probably will be within a few years, it will be desirable to maintain the trestle by proper repairing and reinforcing for a year or two rather than renewing it in kind.

In many cases where the annual charge of the permanent structure is greater than that of a pile or timber frame trestle, the management may decide, if funds are available, to carry out the permanent work as a matter of policy. This practice has been largely followed on many roads in the construction of concrete trestles where the annual charge for interest frequently exceeds the annual charge for the interest and maintenance of a timber structure. One of the considerations influencing such a decision is the fancied greater security in case of derailment or wreck and also the decreased amount of interference with trains caused by the presence of the permanent structure as compared with that caused when repairs and renewals are being made to the timber structures.

Conclusions.

The committee concludes that whatever design may be used, one of the most important considerations is the necessity of having a consistent and comprehensive system of bridge inspection by means of which defects may be discovered and proper remedial measures adopted to keep the bridges safe. Such systems of inspection are customary on every railroad, being carried in more or less detail by all. As an example of the procedure and instructions covering such inspection the general instructions and inspection notes of the Missouri Pacific, given in the last part of the Appendix, are of interest. While these instructions and notes refer generally to all types of bridges visited by the inspectors, they include the various features that must be given attention on pile and timber trestle bridges.

It is recommended that similar instructions and inspection notes modified as may be necessary to fit the local conditions for each road be adopted and put into effect, in order that all concerned in the maintenance of pile and timber trestle bridges may be relieved of all doubt as to their duties and responsibility in connection therewith.

The design, construction, maintenance and renewal of pile and trestle bridges can not be reduced to an exact science. but they will always require the best exercise of the judgment and skill of experienced bridge men. The committee has no doubt that the above considerations will enable the members of this association to arrive at conclusions as to the best method of handling the situation under the conditions obtaining on their roads.

A. B. McVay,
C. E. Smith,
F. G. Jonah,
S. T. Corey,
J. J. Taylor,
E. J. Auge,
A. J. James,
S. C. Tanner,
Committee.

APPENDIX.

To indicate the character of the information furnished in reply to the committee's letter, the following are quoted.

Chicago, St. Paul, Minneapolis & Omaha.

By H. Rettinghouse, Chief Engineer.

We have only one standard. All former standards have been abandoned, although some bridges are still maintained which were constructed under former standard plans.

It is very difficult to give a statement of the conditions under which timber bridges should be repaired, reinforced, etc. Generally bridges are repaired to the point where it is no more economical to do so. Reinforcement is made either on account of portions of the bridge becoming weak through the advanced age of the timber, or by reason of additional requirements on account of heavier power. Renewals or replacements are generally made when the condition of the bridge demands such action. In our experience we find that soil has a great deal of effect on the relative life of piles in some cases. It has been stated but to me not effectively proven that timber and piles placed in bridges, will last longer in the country where the timber grows than if used in other parts of the country. We know of course that dry, sandy soil is very detrimental to the life of piles, wherever it comes in contact with timber.

I have had no experience with the effect of animal or vegetable growth on pile and timber trestles. I have had a few instances in the Wisconsin and Minnesota timber country where porcupines have attacked piles and timber in wooden bridges, due to leakage of brine from barrels filled with water for fire protection. In one or two instances the damage was very great. I have no particular instances to record of destruction due to vegetable growth. We do not use any paint or preservative for pile or timber trestles.

No hard or fast rule can be set down as to the time and manner of making repairs. This is dependent on conditions as shown by inspection. As a rule most of our repairs, except emergency repairs, are made during the summer months. The time to be selected for extensive renewals depends altogether on local conditions. In some cases on large trestles crossing lakes, ponds and marshes, it is advisable to make these renewals during the winter as it is decidedly more economical to do so.

The replacement of pile bridges with similar structures is governed by certain conditions, as to location, the comparative cost of permanent structures and the financial ability of the company. In certain cases pile and timber trestles must be maintained as such, owing to topographical reasons or to the cost of permanent structures being altogether prohibitive. Most railroads, including this company, replace with permanent work a certain portion of the temporary structures each year and naturally such locations are selected for such replacements as offer the most practical and economical results. On this company's lines during the year 1914 there were replaced 5,590 lin. ft. of pile trestles at a total cost of $65,745, or an average cost per lineal foot of $11.76.

In my experience, extending over 30 years, I find the average life of a pile bridge is about 10 years. We make two regular inspections each year, one in the spring and one in the fall, and a mid-summer inspection by our general bridge inspector. Estimates and recommendations are made from a combination of the fall inspection made by the superintendent of bridges and buildings and the mid-summer inspection of the general bridge inspector. Recommendations are made at the end of the year for maintenance and renewal work, and recommendations are also made to the chief engineer for permanent renewals extending over two years in advance.

We have, so far, not used any treated timber, but are contemplating its use in the near future. We do not use ballasted decking, but we use gravel covering for fireproofing purposes.

The Denver & Rio Grande.

By Arthur Ridgway, Assistant Chief Engineer.

We find a great variation in the life of piles, dependent upon soil conditions, and as a result are compelled to place the length of life of our native Douglas fir piles within wide variation, from six to ten years.

No appreciable effects have been observed from animal and vegetable life on our wooden trestles. This is perhaps due to the fact that we operate through semi-arid regions and are not troubled with varied forms of animal and vegetable life. We do not use any paints or preservatives on our wooden trestles.

Emergency repairs are made at any time. We endeavor to make regular repairs after a comprehensive inspection and the preparation of an annual job list.

Individual posts of framed bents are replaced as they become unserviceable. When one or two piles of a pile bent are badly decayed, helper-posts are put in place to carry the structure for a year or two or until all piles should be renewed. Our stringers have quite a uniform length of life and therefore all those in any one bridge begin to fail at about the same time. Such being the case, no reinforcement of stringers is effected, but the chords are renewed as a whole.

Complete renewals are made when the bents and ties are bad and the stringers show signs of decay. This necessitates new bents and new ties. The new bents are usually constructed as close to the old bents as possible and the deck shifted to conform to the position of the new bents. A renewal of the structure in kind is effected when so large a portion thereof needs replacement that it is more economical to rebuild the entire bridge and when no permanent structure is contemplated for its replacement. Although primarily dependent upon financial conditions, a wooden structure is usually replaced by permanent work when the annual saving in maintenance created thereby is shown to be an abnormally large rate of interest on the amount necessarily invested in the permanent structure.

As regards cost for various heights, I beg to advise that between the average height of bents of 16 ft. and 40 ft., the cost per lineal foot of bridge is given very closely by the following formula, where " C " is the cost per lineal foot in dollars, " h " is the average height of all the bents of the bridge in feet, and " 1 " is the length:

$$C=6+\frac{h}{4}-\frac{4h-64}{l}$$

The above formula will not give close results when the average height of all the bents of the bridge is less than 16 ft., or more than 40 ft., and applies only to framed bents on wooden blocking. In many cases we place framed bents on concrete foot walls, for which type of construction I can give no general costs.

On account of the variation in soil conditions in the mountains it is difficult to arrive at definite figures as to the length of life of the substructures of our trestle bridges. About the only definite information as to the lasting qualities which we are able to substantiate is with respect to Douglas fir stringers, which we secure from Oregon. Under favorable conditions our stringers will last 20 years, and begin to decay first on that portion of the surface in contact with the ties.

Inspection is made by the superintendent of bridges and buildings with the assistance of one of the different supervisors, and every portion of the structures is thoroughly gone over.

We have not thus far used any treated timber whatever on our wooden bridges.

Our wooden bridges are protected against fire by enclosing the space between the ties and covering the entire surface with 2-½ in. to 4 in. of gravel, broken rock, or crushed slag.

Great Northern.

By John A. Bohland, Bridge Engineer.

Up to this year we have been using 8 in. by 16 in. stringers in connection with our standard pile and timber trestle bridges and we are still continuing the use of 8 in. by 16 in. stringers on branch lines. It is not our policy to use two standards and the above standard for branch lines will no doubt be discontinued after a few years. The main reason for adopting it at this time was to apply any 8 in. by 16 in. stringers which we had on hand or on order.

The conditions under which pile and trestle bridges should be repaired, reinforced, renewed or replaced vary greatly from year to year and depend wholly upon the amount of money the executive officers are willing to spend. In making up our annual recommendations, it is our practice to show the estimated cost of repairs to carry one year the estimated cost for renewal in kind and the estimated cost for a permanent structure. The above list does not contain any bridges where only light repairs are required but only such bridges as could be legitimately considered for replacement with permanent structures.

Our method of inspection is as follows: We have on each operating division a master carpenter who has charge of the repairs to bridges and buildings. The annual inspection for maintenance is usually made in September by the master carpenter accompanied by a representative of the engineering department. The notes taken at this time are then worked up by our resident engineer, making a work sheet for each division, and material is ordered by the latter. In addition to this annual inspection the master carpenter makes frequent inspections of his division without making any report to the engineering department, except during his annual spring inspection on which he does report and arrangements are made for such additional repairs or material required and not covered by annual fall inspection.

We do not use treated timber or ballasted decks in connection with our pile and timber trestle bridges.

Lehigh Valley.

By E. B. Ashby, Chief Engineer.

Repairs should be made when the general condition of the structures requires it, placing new stringers, caps, sills and braces to replace decayed ones, provided at least 50 per cent of the material in the structure is in good condition or in such condition that it will last at least two or more years. If more than 50 per cent of the members above enumerated are poor, the whole should be replaced and the good material taken out used in making smaller repairs on other structures. If posts or piles are decayed at the bearings, some may be cut off and short pieces spliced in, making good bearings, using scabs, and bolting securely. In no case should more than two posts or piles in a bent be treated in that manner. If piles decay at the ground line for a short distance a single or double sill inserted near the ground line may permit the cutting out of the decayed part. When piles are driven in water-carrying soil, and the exposed parts are decayed, they may be cut off below the water line and framed trestle bents placed upon them.

I do not consider it good practice or economy to replace a few pieces of timber here and there, leaving any questionable material in place, and in a short time returning to the same structure and taking out a few more members. This method keeps the structures in questionable condition at all times. Where a large number of wooden structures have to be maintained on a line it is better practice to renew a certain number every season and use the good material taken out for repairs at other structures.

The condition of the soil, as well as the climate, affects the lasting qualities of timber. Alternate wet and dry soil will cause decay of any timber near the ground line. Vegetable life around structures should be kept down on account of the danger from fire as well as the damage from moisture carried to the timbers.

Reinforcement of bents and stringers may be effected by adding more posts and additional lines of stringers. Care must be taken to provide sufficient support on the soil for the bents with the understanding that the strengthening is done for heavier loads. For long spans additional bents may be economical.

The replacement of wooden structures in kind will always be cheaper than replacement by permanent structures. It depends on the character of railroad and traffic conditions when permanent structures should be considered. Creosoted timber structures furnish a semi-permanent structure if properly constructed and good treated timber is used. We have comparatively few wooden trestles on our line. We have started to replace open wooden trestles with ballasted floor creosoted timber trestles, but can not as yet form an idea as to their economy. Wooden trestles painted with so-called fire-resisting paints, should give additional length of service and be protected against fire, if properly done and repeated at the proper time. I have had no experience with these.

We have a bridge inspector on each division whose duty it is to inspect all bridges and structures at all times going from one structure to another and making special inspection of structures requiring it. By this method we keep thoroughly posted from the reports made monthly by the division engineer and from special reports in cases of necessity.

The length of life of wooden structures on our line ranges from 8 to 12 years, depending on local conditions, the condition of the timber when placed and the amount of traffic carried. Creosoted timber trestles are estimated to have twice the life of untreated ones, but I have no data as yet indicating whether this will be realized.

Louisville & Nashville.

By F. A. Busse, Bridge Engineer.

Green timber trestle bridges are generally renewed or replaced when the cost of repairs will amount to as much as 50 per cent of the cost of rebuilding them with green timber. Green timber is not used for the construction of trestle bridges except where the structures are of a temporary nature. All existing timber trestles are either renewed with creosoted timber or replaced by fill embankments or other permanent structures. On main line we endeavor to replace all timber construction with permanent work. Whenever timber trestle bridges come up for renewal, a careful investigation is made to determine whether it is practicable to fill them. The estimated cost of providing the necessary culverts and underpasses and filling embankments is compared with the capitalized cost of renewing the trestle with creosoted timber and of renewing it with green timber. The capitalized value of creosoted trestle is based on a life of 24 years. The capitalized cost of green trestle is based on a life of 8 years. The rate of compound interest is placed at 4 per cent. Whenever the estimated cost of the permanent construction, including the fill, is equal to, or only a slight amount more than the capitalized cost of a creosoted trestle, permanent construction is used. On branch lines of low earning power, this procedure is not always adopted, and careful consideration is also given to the first cost.

A ballast deck is used on all creosoted timber trestles except those along the gulf. It is advisable to use a ballasted deck on account of the better riding track. They are also safer for derailed trains, and because of fire protection. The open deck trestles are in danger of fires started by hot coals dropping from the ash pans of passing engines. A hot coal is likely to lodge in a corner where bracing is attached to the pile or poles and a number of creosoted trestles have been set on fire in this way.

The estimated cost of a creosoted timber ballasted deck trestle varies from $14 per lineal foot of track for trestles 10 ft. high, to $31 per ft. for trestles 60 ft. high. We ordinarily estimate the life of a creosoted timber ballasted deck trestle to be 24 years and we have trestles on our system that have exceeded this life. Creosoted timber has been used in the construction of timber trestles on one division for about 40 years. It was adopted for the construction of all timber trestles on the system about 12 years ago and has given good satisfaction.

Seaboard Air Line.

By J. C. Nelson, Engineer Maintenance of Way.

Conditions governing the repairs, reinforcing, renewals or replacement are variable. I know of no fixed rule that could with good practice be applied in general. The usual course pursued is to make a close inspection of each structure to determine what material is needed to keep it in good physical condition for one year. With this information and the known average life of the timber, the practical inspector should know which of the remedies to apply to each structure or portion thereof.

Timber will decay quicker in a hot, dry climate than in a dry, temperate climate. Dry, sandy soil will rot timber sooner than where it is moist and wet. Vegetation such as long weeds, grass or bushes and vines will cause timber to decay sooner than if kept free from them.

We do not use any paints with a view to preserving trestle timbers. Experience has shown that unless the timber is thoroughly dry, paint does not protect it from decay. The only preservative we use is creosote applied with pressure. We have experimented some with toredo-proof paints on pine piles, but not long enough to determine their effectiveness.

Climatic conditions permit our repairs to be carried on throughout the whole year. We do not reinforce stringers; replacing is considered the better way. Reinforcing of pile and frame bents is frequently resorted to by driving pile bents midway betwen the bents to be strengthened and capping them. This method is usually carried out over the whole length of a trestle. This practice prolongs the life of the stringers as well as reinforcing the old bents. We also replace defective pile bents by cutting them off below the ground or water surface and placing thereon frame bents. This practice does very well with low trestles and where flood waters are not destructive.

Variable conditions govern replacement with permanent work, i. e., the cost of maintenance as against interest charges on the capital invested in betterments, and the relative costs of replacements and betterments on permanent structure, the location and the hazard.

The average cost of standard main line open deck trestles requiring 35-ft. piles is $7 per lineal foot, and of ballast deck trestles, $12 per lineal foot. The average life of long leaf pine timber is 7 years. An annual inspection is made of all trestles by the master carpenters on their respective divisions accompanied by the general bridge inspector. This inspection is carried out in detail and a record is made on the spot as to the condition, requirements and changes needed and proposed. From these records estimates are made later on to cover the annual cost of maintenance. Besides this, the master carpenters make monthly inspections.

We use creosoted timber and piling for ballast deck trestles. On the open deck trestles we use No. 24 galvanized sheet iron to cover the stringers principally as a protection against fire.

Instructions Regarding the Inspection of Bridges, Culverts and Waterways on the Missouri Pacific.

Regular inspection of all bridges, culverts and waterways shall be made as follows:

Section foremen shall give similar attention to each bridge, culvert and channel each time they inspect the track. At least once each week and immediately following any unusual storms, casualties or other unusual occurrences, they shall stop and carefully examine each of such structures.

Supervisors, experienced bridge foremen or inspectors shall make inspections at intervals of approximately 6 weeks with such additional and more frequent inspections of certain structures by the supervisor or his proper representative, as may be necessary in special cases.

Roadmasters, when passing over their track, shall give similar attention to the condition of bridges and culverts. In an emergency they shall report by wire to the division superintendent for immediate attention such repairs as they may deem necessary for safety.

The bridge engineer or his inspectors shall inspect, every six months, all girders, trusses, draw-bridges, large trestles and other bridges which may require such inspection, and shall examine the supervisor's inspection notes to see that the inspections are being carried out according to instructions. Records of such inspections shall be kept in the bridge engineer's office and information setting forth the conditions found by such inspections shall be furnished engineering and operating officers to such extent as may be necessary. This inspection may be merged with the fall inspection mentioned below.

A special inspection shall be made each fall, generally during October and November, from which additional information will be derived for determining the program for renewal, reconstruction, and general repairs during the ensuing year. This inspection shall be made by the engineer maintenance of way or an engineering department representative expert with reference to bridges, delegated by the authority of the chief engineer and the supervisor. In addition the general roadmaster, division engineer, or superintendent, whichever is in charge of the working forces, and the bridge engineer shall accompany the inspection parties as much as possible.

Copies of the notes of the fall inspection, which will be taken by the engineering department representative, will be furnished the supervisor, the superintendent, the engineer maintenance of way and the bridge engineer. The latter shall specify the improvement items which must be given special attention, each of such items to be worked out on its merits and covered by an A. F. E.

Recommendations for permanent structures shall be checked by the engineer maintenance of way and bridge engineer. The engineer maintenance of way shall certify to the sufficiency of the waterway, and that the proposed improvement will not interfere with possible changes in grade and alignment. The bridge engineer shall certify to the adaptability of the proposed structure and jointly with the engineer maintenance of way shall certify to the sufficiency of the waterway.

From the report of inspection and examination, as above, the character and extent of renewals and improvements will be determined. All changes, additions or expensive renewals of bridges, culverts or other important structures, shall be made only upon properly approved plans, estimates and instructions of the engineering department, and when authorized by an approved A. F. E.

The receipt by the operating officers of a copy of the notes of the fall inspection, shall be understood as instructions for them to arrange for and to proceed with all repair items on bridges except those that will be covered by A. F. E.'s.

It will be the duty of the general roadmaster, division engineer or superintendent, (whichever is in charge of the working forces on the division) to give bridge inspection and maintenance such attention as will insure that inspections are being made as required, that the work is proceeding consistent with the inspection notes, and that the structures are being maintained safely.

The roadmaster shall arrange to obtain the records of extreme high water at the time of each flood or extraordinary freshet, at all bridges, culverts and openings. Section foremen shall be instructed to go over their sections at such times and take the measurements from top of tie to the extreme high water mark, and report such measurements, giving the number of the bridge or opening to the roadmaster, who will furnish the information to the superintendent. The superintendent will forward copies of this data to the bridge engineer and engineer maintenance of way for record.

Monthly reports on the proper blanks shall be made by the supervisors, through the division office to the bridge engineer.

Instructions to Inspectors.

(The numbers and directions in the inspection notes correspond with the numbers and abbreviations on the report blanks.)

Inspection note books shall be filled out at each structure after a careful examination has been made of each of the points itemized in the blanks, using in cases where there are a number of spans in which defects are observed, a properly noted column for each span. When the spans are all in good condition, one column only need be used, but the number of spans should be noted.

Designate the separate spans of a bridge by numbering them in the direction of the bridge numbers on the division, and the separate bents or piers in the same manner, commencing with the abutment, bank bent or sill as number one. Designate the truss as the right or left, locating points on it by numbering the panels in the same direction as the spans are numbered.

When wooden structures are six or more years old, such members as by their position are particularly liable to decay shall be tested by boring, the holes being plugged up as soon as the inspection is completed.

When making the regular inspections the inspectors shall make a statement of the results of the last examination relative to such structures as required attention at that time, and in reporting on these structures, special note shall be made as to whether or not the repairs and recommendations of the previous examinations have been fully carried out, and whether the work is in accordance with the standard plans.

Inspection Notes.

1. Does the waterway require straightening, cleaning out or enlarging above or below the structure? Does the structure afford ample waterway? Is riprap needed to maintain the channel or protect the roadway?
2. Note the line and surface, also the condition of rails, joints and fastenings on bridges and approaches. See that rails are braced on curves where necessary, and that the track on the approaches is firmly bedded, avoiding shock or jolt to a train as it passes on to the bridge.
3. Note any rotten, split or otherwise defective bridge ties, giving the number, size and kind.
4. See if the guard rails are in line and bolted or spiked down tight. See if they are sound.
5. Note the condition of caps and stringers, particularly at points where they bear against other members.
6. Note if plumb and batter posts are crooked, split or decayed, and if the bents stand plumb.
7. See if trestle towers or bents are properly sway-braced, and all

braces longitudinal and transverse are drawn up tight and have sufficient bolts or spikes to hold them properly.

8. Note particularly the condition of piles where they enter the ground or water. See that they stand properly.

9. Examine each pier and abutment as to joints, settlement, imperfect stones, cracks and other defects. Note if the work needs pointing or if cracks have opened since the last inspection. If the masonry is cracked or if any settlement or movement is detected, make such sketches and record such measurements as will enable the kind and amount of motion to be determined on a later inspection.

10. Note the condition of pedestal stones and make note of any debris on the bridge seats or around bridge bearings. Note if water collects on bridge seats and how the trouble can be remedied.

11. Note the condition of riprap, if any. If riprap is needed to protect foundations from scour, make note of the quantity required.

12. Note the condition of culverts and retaining walls and see if they are yielding by settlement or bulging from the pressure of the embankment.

13. Note the condition of the ring or covering stone of box or arch culverts.

14. Note the condition of paving and riprap, and see that same is so placed that it can not be undermined by washing.

15. Does culvert pipe need head or tail walls to protect the embankment from washing? Does it clean itself of water? Are any joints settled down or broken in?

16. Does a timber box need to be replaced with masonry or culvert pipe? If so, give the dimensions required to give ample waterway, and give the height from bottom of stream to rail.

17. See if bed plates and rollers are clean, and if the latter stand so as to move squarely back and forth with the trusses. See if the pedestals take even bearing on the rollers. Examine anchor bolts.

18. Observe particularly the condition of all timbers where corbels, wall plates or bolsters rest upon them. Note any appearance of crushing or decay.

19. Angle blocks and all cast iron members such as chord boxes, post shoes, etc., must be examined for cracks and for any indication of displacement by reason of the daps splitting or the timber crushing. A hole ¼ in. in diameter, if drilled at the end of a crack, will frequently stop its extending farther.

20. See that all chord and packing bolts are tight. Nuts on all bolts through guard rails, ties, stringers and floor beams must be secured in place by burring the threads of the bolts at two or three places with a center punch or cape chisel.

21. Note the condition of the galvanized iron covering of chords and end posts of combination spans and of stringers and caps in trestles.

22. Notice particularly the connections between stringers and floor beams; note if connecting angles are split, either in the angle or through the line of the rivet holes. Note the condition of the wooden stringers as to soundness and bearings.

23. Notice particularly the connection between floor beams and trusses for evidence of imperfect bearing, or splitting of the connecting angles. If suspended, notice if they are up tight against the post feet, or are free to move.

24. Test the equality of the tension in the tie bars by springing them. Look for any signs of distortion or crookedness in the bars of the end panels of bottom chords. Counter, lateral and vibration rods must never be allowed to hang loose. They must not be adjusted while a load is on the bridge. They should be tightened enough to give close and even bearings, but must not be overstrained, as unnecessary strains are put in compression members, if too much power is used in adjusting tension members. See that the center line of all tension members is the same as the line of strain.

25. See if posts, lateral struts and top chords are straight and free from twists. On wooden bridges see if braces are up in place, taking a square bearing at the ends, and note if any warping is evident. Note their condition as to soundness.

26. Examine all lateral connections, and see that lateral tension members are straight. Examine the bracing in steel trestles.

27. Make particular examination of all hangers, testing each nut to see that it is tight. A streak of white paint drawn across the nut and bearing will indicate any movement. These nuts should be screwed up tight and secured by burring the thread of the bolt and nut at two or three points with a center punch or cape chisel.

28. Note any pins which indicate movement of the members coupling on them, or that have loose nuts. All pins and nuts should have a streak of white paint across the nut and pin end.

29. All field-driven rivets in floor beams and stringer connections and in the bottom of chord splices should be sounded lightly to see if they are tight, also lateral connection rivets in riveted trusses, and any intersection or other rivets which indicate by rust streaks or otherwise, that there is movement at that point.

30. Note if there are any members, such as closed columns, pedestals, etc., which catch and retain water by reason of not having proper drain holes.

31. Note carefully the line of each truss by the top chord and by points on the floor beams equi-distant from the centers of the posts. Also note by the top and bottom chords whether the camber is true and uniform or irregular.

32. Look for loose rods, hangers, loose braces, unequal sized timbers and other defects which require adjusting in order that each of the different parts may have proper bearings and carry its proper part of the load.

33. Note any undue vibration or excessive deflection of the structure under live load, seeing if the two trusses have the same deflection.

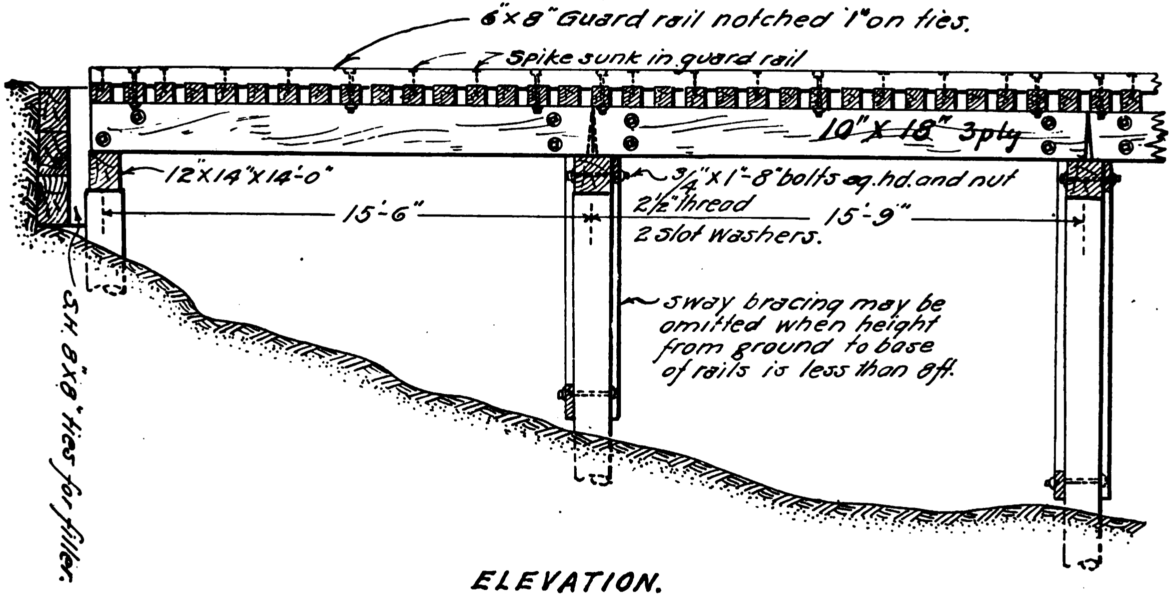
34. See if any rust spots are apparent under the paint. Note if the structure needs repainting. Steel bridge work should be scraped and repainted as often as necessary to preserve from rusting. If painted recently, note the quality of the work.

35. Note such wooden structures as require barrels to add to their safety, giving the number required. State the condition of such barrels as may be in position. On all bridges of such magnitude as to require a watchman, there should be a foot plank between the rails, securely fastened to the ties to facilitate crossing the bridge quickly in emergencies, such as fire or danger to trains. Note if ladders, either fixed or portable, are required for the safety of the structure or to facilitate inspection.

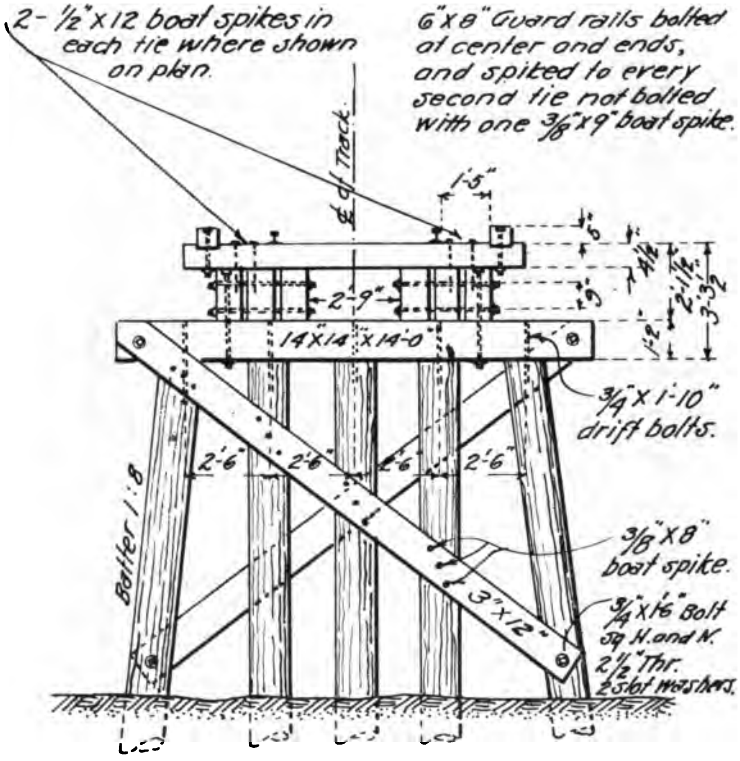
36. See if material, driftwood, weeds, grass or other rubbish is properly removed and burned, or otherwise disposed of.

37. Note and report how much one end of a span kicks up when a train is on the opposite half of the span. Examine the end wedges for full and even bearing when driven. Examine worms and worm wheels for wear and breakage. Examine the shafting and gears to detect loose boxes and couplings, lost keys and broken or cracked gear teeth. Note the condition of the track at the ends of the span. Examine end ties, rail locks and rail sections to detect wear and loss of rigidity.

Note if the bearings under the end wedges are bolted down securely to piers. See that wedges, worms and bearings are properly cleaned and lubricated and that no accumulation of dirt or rubbish is permitted around center or end machinery. Note if friction clutches on the engine are worn or otherwise out of order. Note the general condition of machinery as to cleanliness, lubrication and adjustment.


6"x8" Guard rail notched 1" on ties.
Spike sunk in guard rail
10"x18" 3 ply
12"x14"x14'-0"
3/4"x1'-8" bolts sq. hd. and nut
2 1/2" thread
2 slot washers.
15'-6"
15'-9"
sway bracing may be omitted when height from ground to base of rails is less than 8 ft.
S.H. 8"x8" ties for filler.
ELEVATION.

Standard Three-Stringer Pile Bridge, For First Class Lines.
Chicago, Milwaukee & St. Paul Ry.

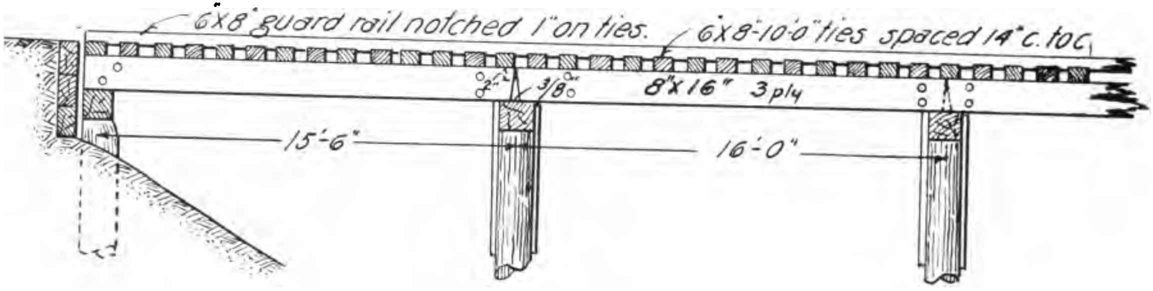

2- ½"x12 boat spikes in each tie where shown on plan.
6"x8" Guard rails bolted at center and ends, and spiked to every second tie not bolted with one ⅜"x9" boat spike.
℄ of Track
1'-5"
6"
4½
9"
1'-2"
2'-1½"
3'-3½"
2'-9"
14"x14"x14'-0"
¾"x1'-10" drift bolts.
2'-6"
2'-6"
2'-6"
2'-6"
Batter 1:8
⅜"x8" boat spike.
3"x12"
¾"x16" Bolt Sq. H. and N. 2½" Thr. 2 slot washers.

NOTE: Ends of all stringers must be so cut that they will abut against each other for 2" down from top and leave an air space of ⅜" between their ends at the bottom.

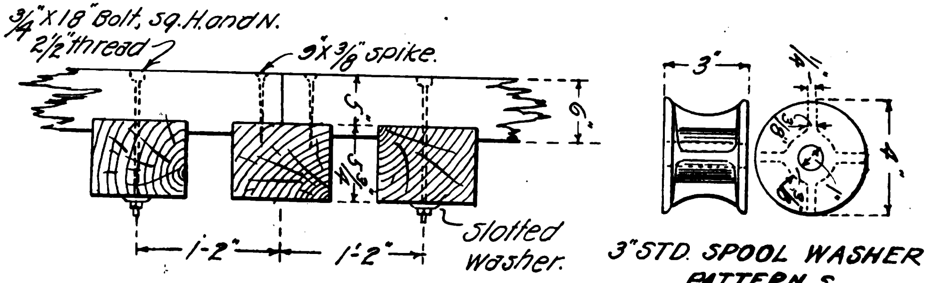
On sharp curves where it is impracticable to spring the timbers, the three stringers in one chord may be cut on the same cap, but both chords must not be cut on any one bent in any case.

Stress on extreme fibre of stringes shown on this drawing is 1475 lbs. per sq. in. without impact for E-55 loading. Bearing on piles for same loading is 16¾ tons per pile for the 5 pile bents shown. Where character of driving does not warrant loading piles to 16¾ tons the number of piles per bent shown may be increased.

Standard Three-Stringer Pile Bridge, C. M. & St. P. Ry.


6"x8" guard rail notched 1" on ties.
6"x8"-10'-0" ties spaced 14" c. to c.
8"x16" 3 ply
3/8"
2"
15'-6"
16'-0"

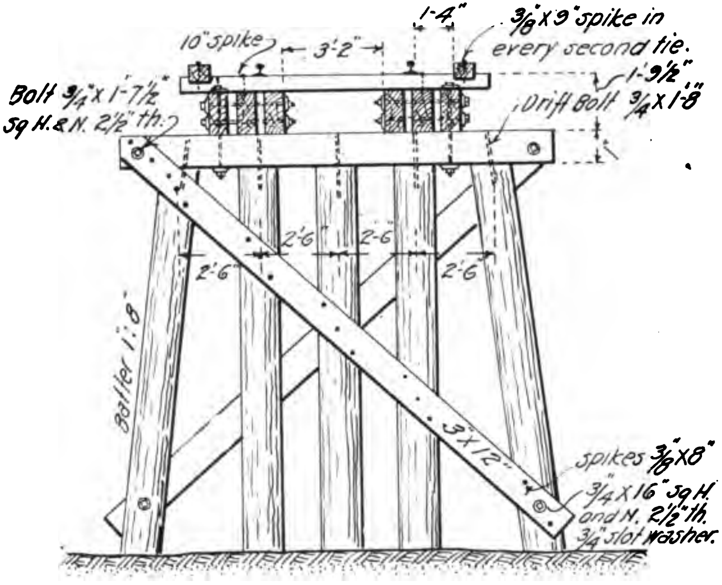
ELEVATION.



DETAIL OF GUARD RAIL JOINT.

3" STD. SPOOL WASHER PATTERN S.

Standard Three-Stringer Pile Bridge, Chicago, Milwaukee & St. Paul Ry.



SECTION.

NOTE.

6"x8" Guard rails bolted at center and ends and spiked to every second tie not bolted with one 9"x 3/8" spike.

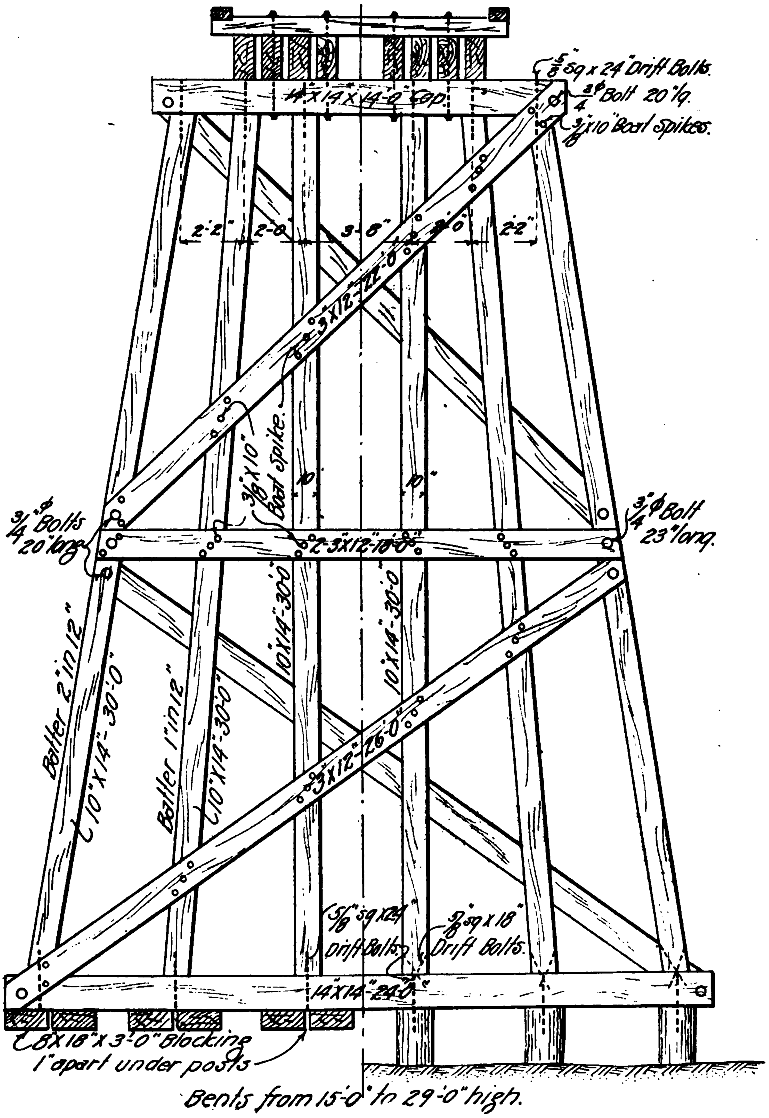
Ends of stringers must be so cut that they will abut against each other for 2" down from the top, and leave an air space for 3/8" between their ends at bottom.

At bank bents a 6" air space must be provided by separating strips.

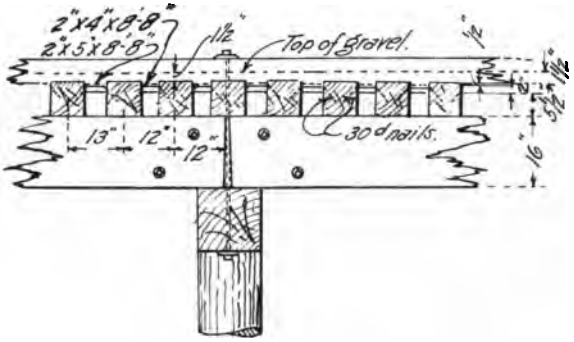
Standard caps are to be 12"x14" with the 14" side horizontal.

Brace plank may be omitted when height from ground to base of rail is less than 8 ft.

Standard Three-Stringer Pile Bridge, C. M. & St. P. Ry

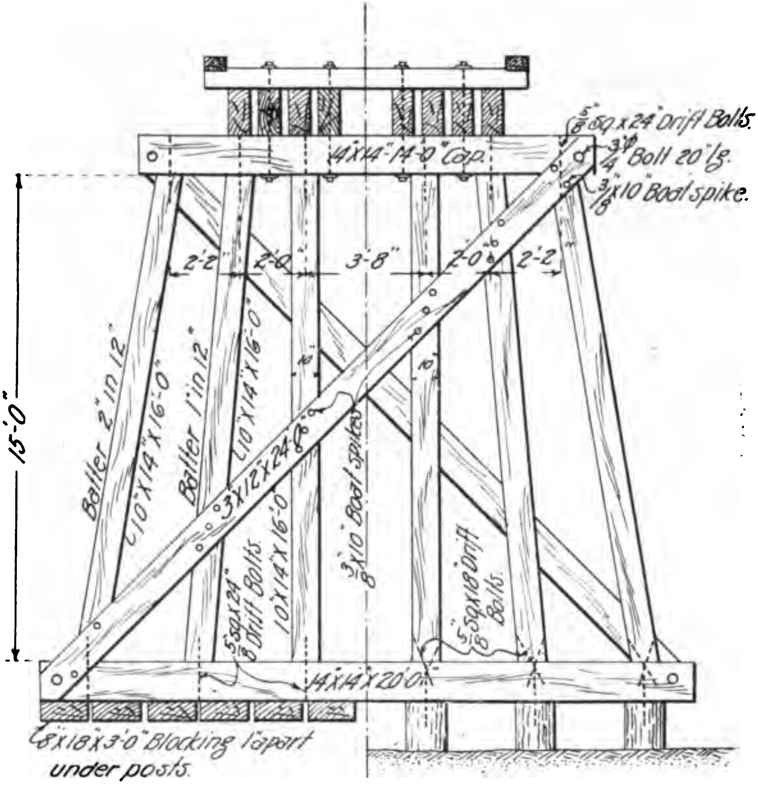


Standard Trestle Bridge, Denver & Rio Grande R. R.



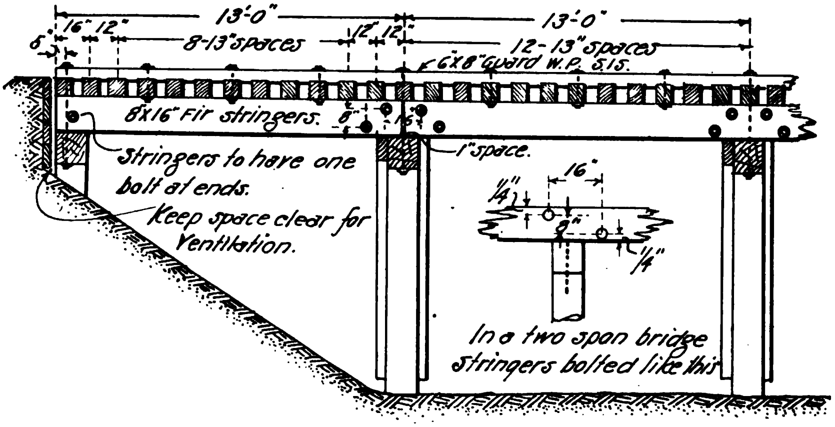
DETAIL ELEVATION
Showing standard pile bridge with
2"x4" and 2"x5" planking between ties
where gravel fire protection is used

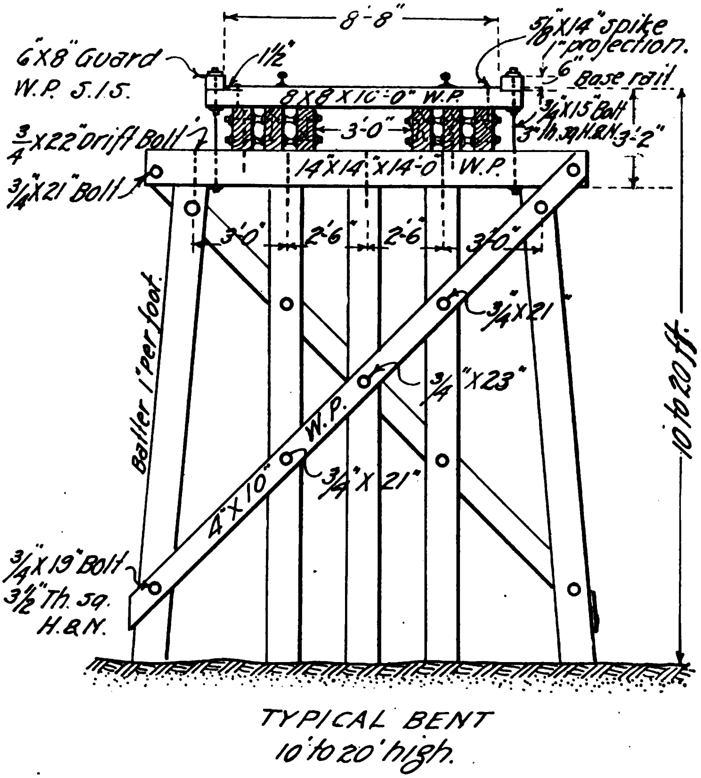
Chicago, St. Paul, Minneapolis & Omaha Ry.



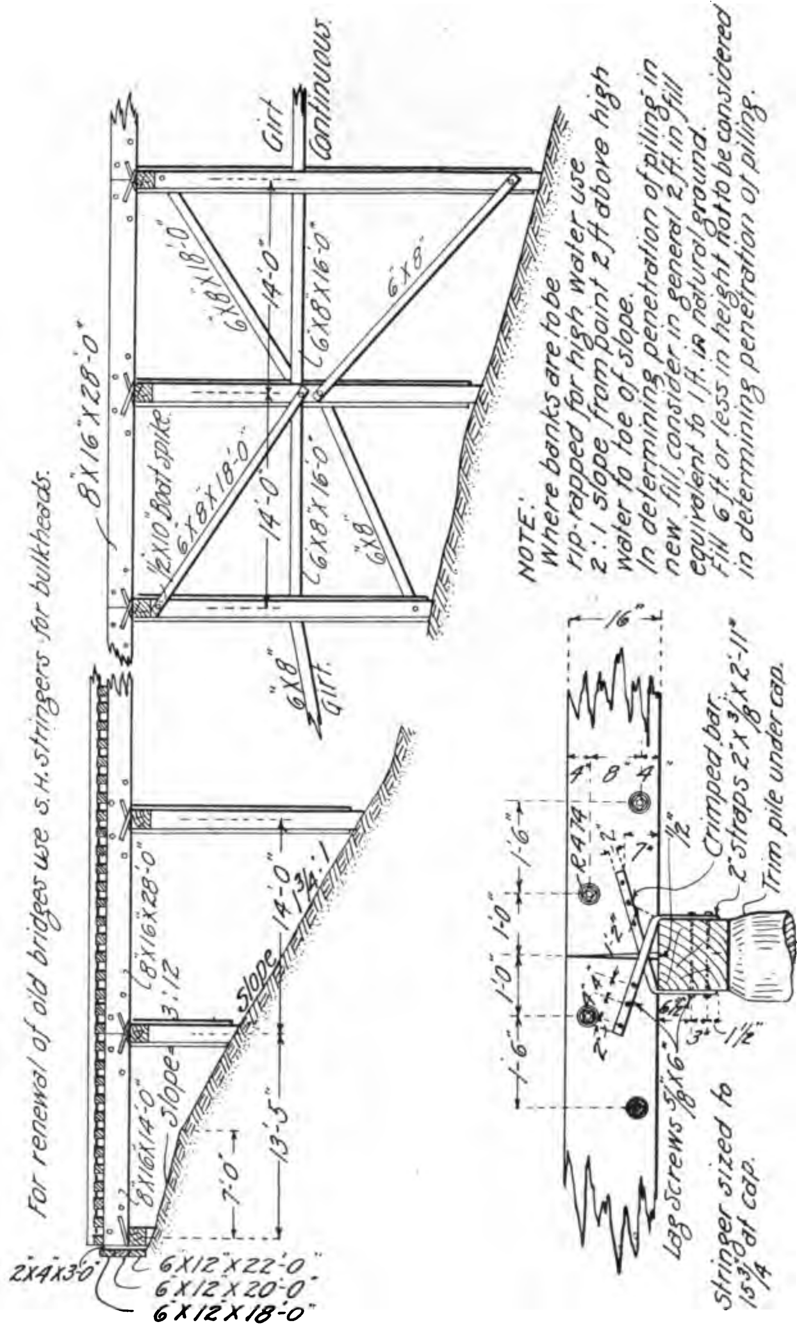
Bents up to 15'-0" high.

Standard Trestle Bridge, Denver & Rio Grande R. R.



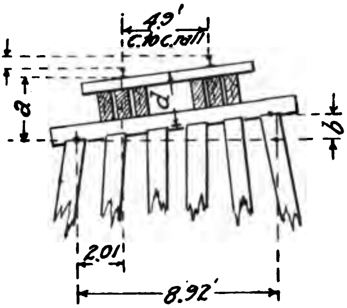


Standard 13-Ft. Span Pile Bridge, C. St. P. M. & O. Ry.



NOTE:
Where banks are to be rip-rapped for high water use 2:1 slope from point 2 ft above high water to toe of slope.
In determining penetration of piling in new fill, consider in general 2 ft. in fill equivalent to 1 ft. in natural ground.
Fill 6 ft. or less in height not to be considered in determining penetration of piling.

Standard Pile Trestle, Great Northern Ry.



$c =$ Superelevation

$d =$ Tie + stringer + cap = 3'-0½" allowance being made for framing and surfacing.

$b = \frac{8.92}{4.9} c = 1.82 c$

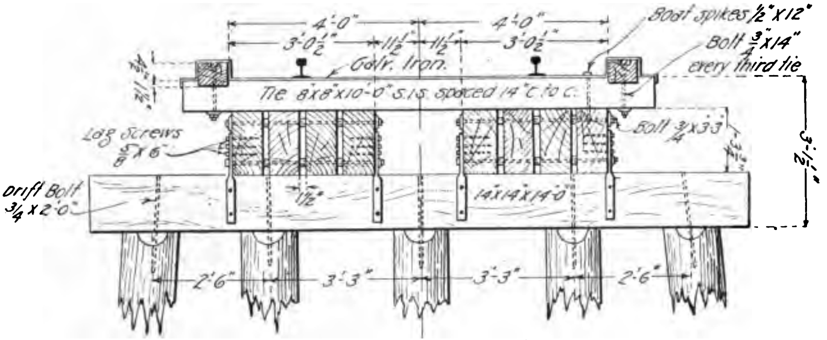
$a = d + \frac{2.01}{4.9} c = d + 0.41 c$

In designing bridges on curves give dimensions a, b, c and d.

For value of "c" use G. N. Ry. table of superelevations with a maximum of 5 inches.

Speed to be determined by Engr. Const. or Eng. M. of W.

Superelevation on Curves, Great Northern Ry.



SECTION THRU FLOOR.

NOTE

Trainman's walk to be placed on bridges coming between or within 500 feet of headblocks.

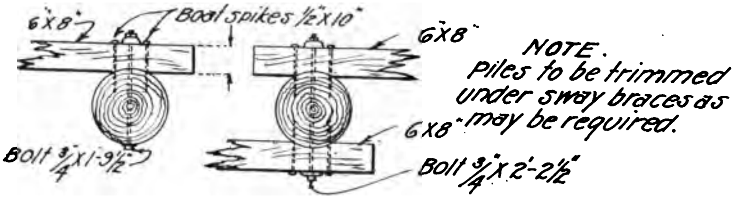
All lengths of bolts given are under head

All bolts to have washers R. 474 at each end except guard rail bolts for which see detail.

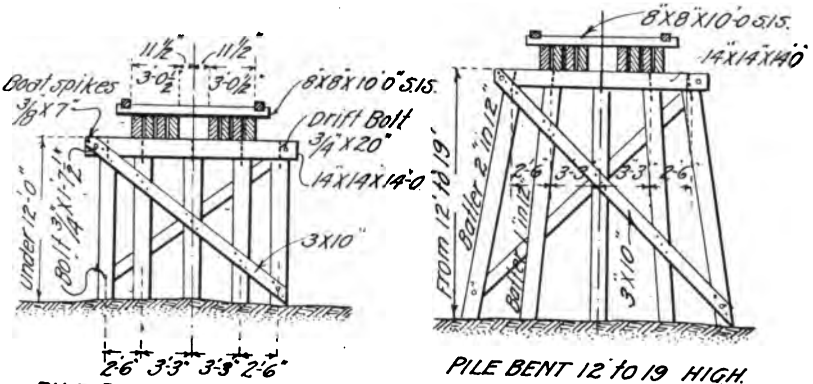
Nuts of all bolts to be checked with 10d nail

Timber bridges to have Galv. Iron decks except in oil burning districts.

Standard Pile Trestle, Great Northern Ry.

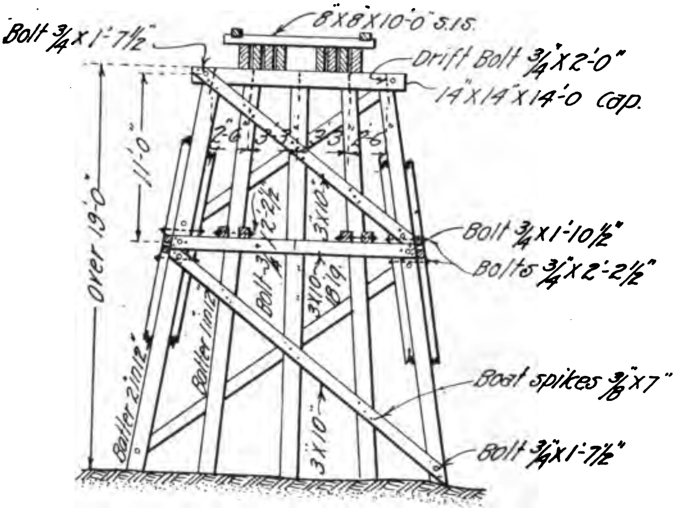


DETAILS OF GIRT JOINT.



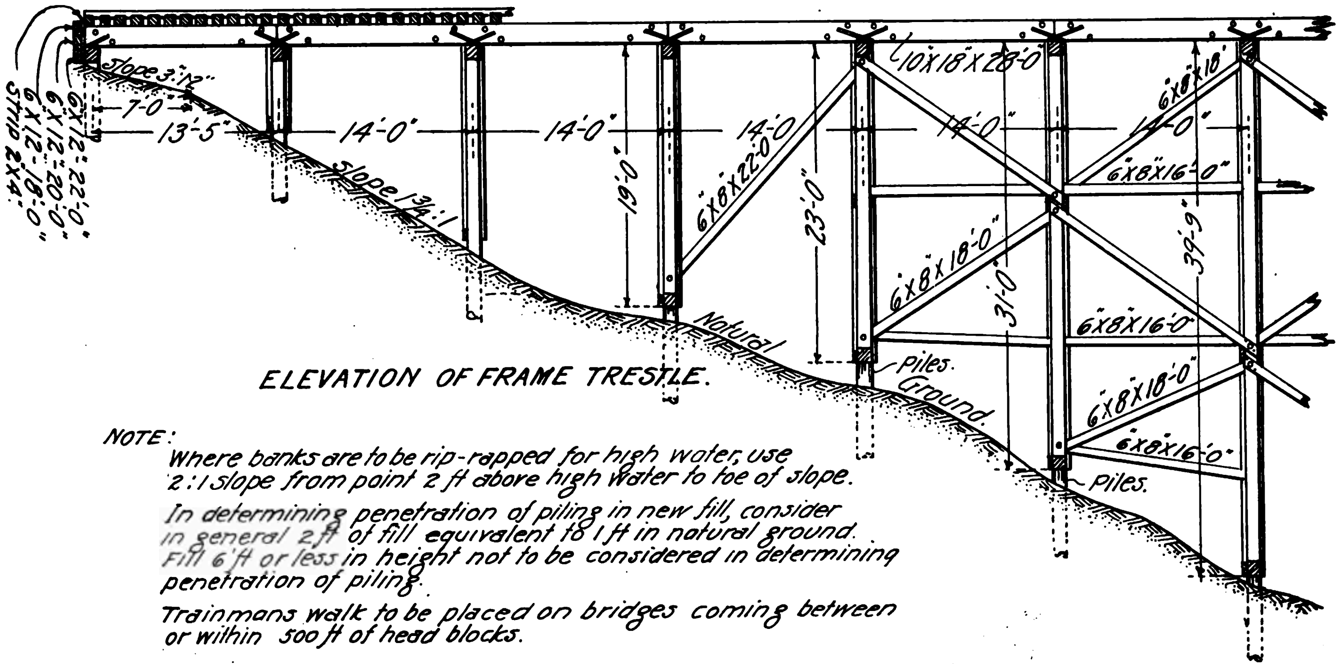
PILE BENT UNDER 12'-0"

PILE BENT 12' to 19' HIGH.



PILE BENT OVER 19' HIGH.

Standard Pile Bridge, Great Northern Ry.



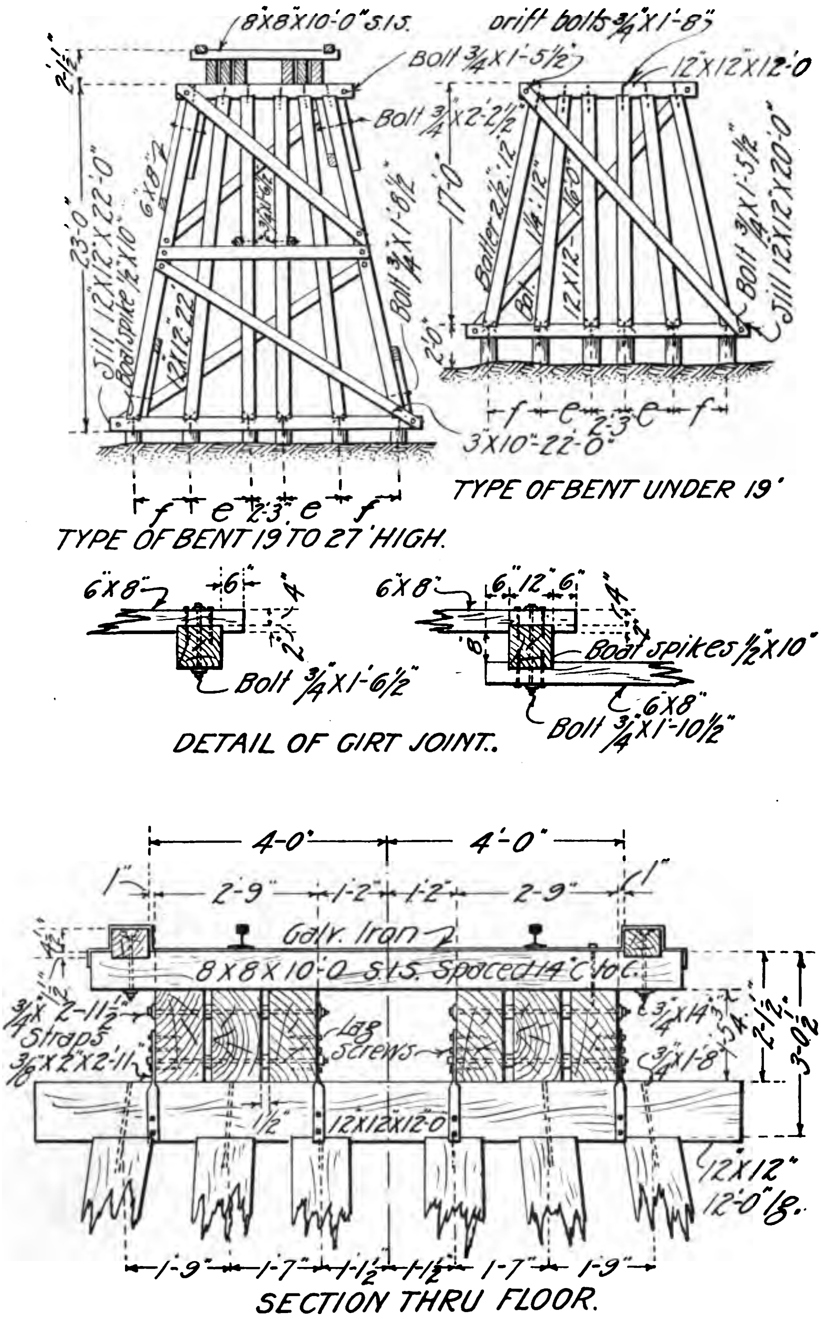
ELEVATION OF FRAME TRESTLE.

NOTE:
Where banks are to be rip-rapped for high water, use 2:1 slope from point 2 ft above high water to toe of slope.

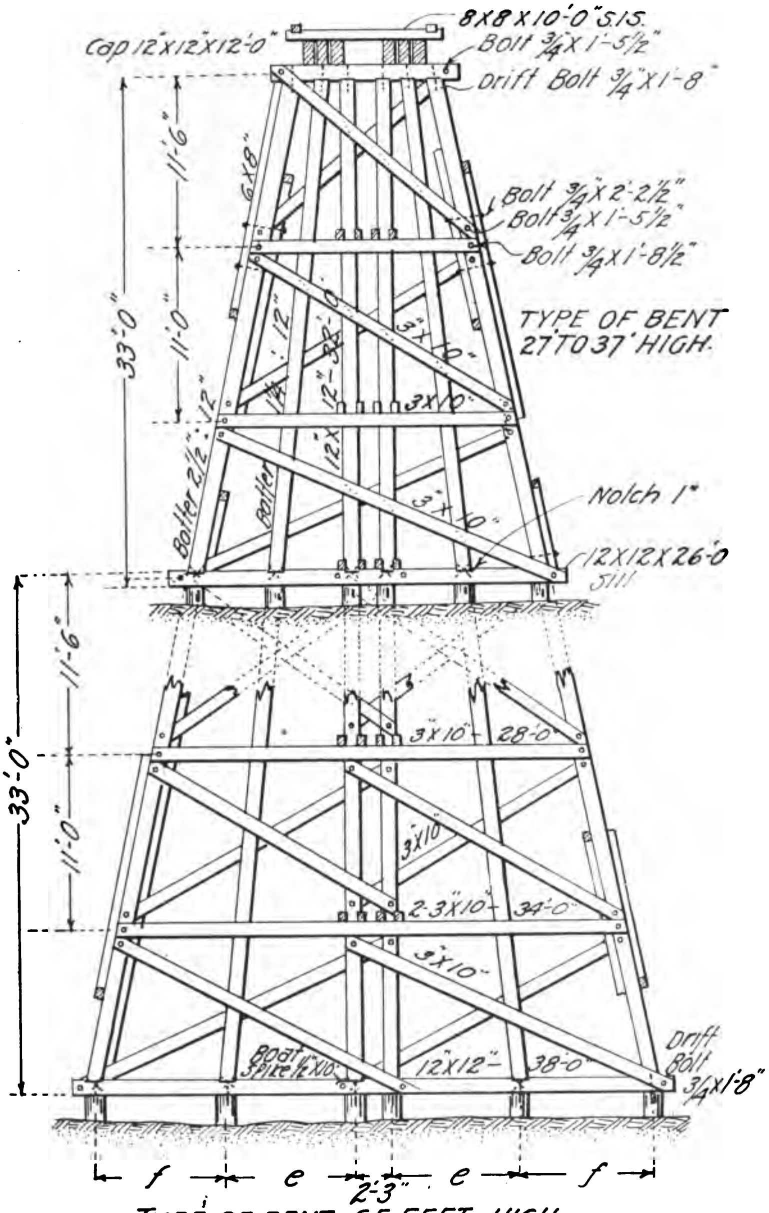
In determining penetration of piling in new fill, consider in general 2 ft of fill equivalent to 1 ft in natural ground. Fill 6 ft or less in height not to be considered in determining penetration of piling.

Trainmans walk to be placed on bridges coming between or within 500 ft of head blocks.

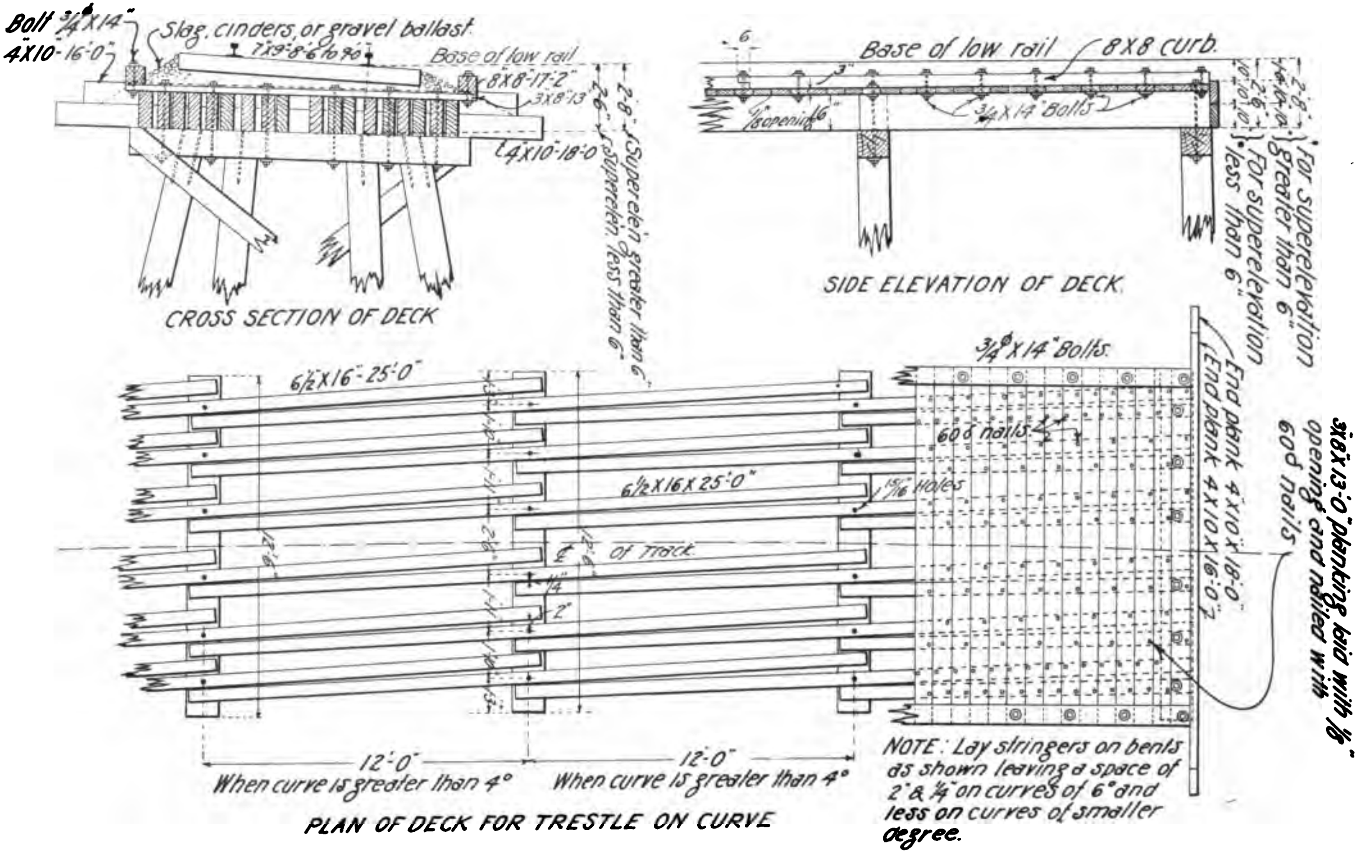
Standard Frame Trestle, Great Northern Ry.



Standard Frame Trestle, Great Northern Ry.



Standard Frame Trestle, Great Northern Ry.

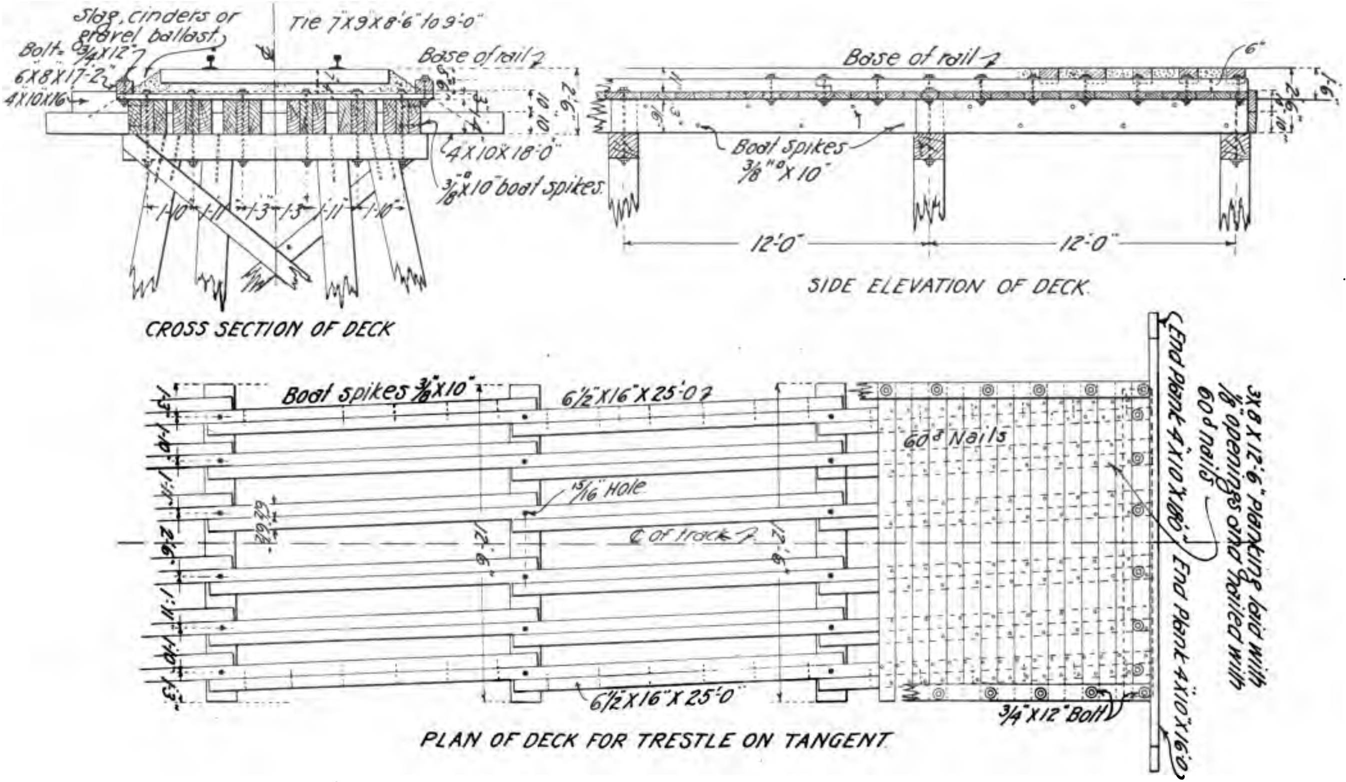

CROSS SECTION OF DECK

SIDE ELEVATION OF DECK

PLAN OF DECK FOR TRESTLE ON CURVE

Bolt 3/4"⌀ X 14"
4"X10"-16'-0"
Slag, cinders, or gravel ballast
7"X9"-8'-6" to 9'-0"
Base of low rail
8"X8"-17'-2"
3"X8"-13'
4"X10"-18'-0
2'-8" Superelev'n greater than 6"
2'-6" Superelev'n less than 6"
6
Base of low rail
8X8 curb.
3"
3/4"X14" Bolts
1/8" opening
6"
2'-8" 10-10-10 For superelevation greater than 6"
2'-6" 10"-10"-10" For superelevation less than 6"
3"X8"X13'-0" planking laid with 1/8" opening and nailed with 60d nails
End plank 4"X10"X18'-0"
End plank 4X10X16'-0"
3/4"⌀X14" Bolts.
60d nails
15/16" Holes
6 1/2"X16"-25'-0"
6 1/2X16X25'-0"
12'-6"
12'-6"
℄ of Track
1/4"
2"
1'-3
1'-10
1'-11
2'-6"
1'-11
1'-10
1'-3
12'-0" When curve is greater than 4°
12'-0" When curve is greater than 4°
NOTE: Lay stringers on bents as shown leaving a space of 2" & 1/4" on curves of 6° and less on curves of smaller degree.

Standard Trestle Bridge on Curves, Louisville & Nashville R. R.

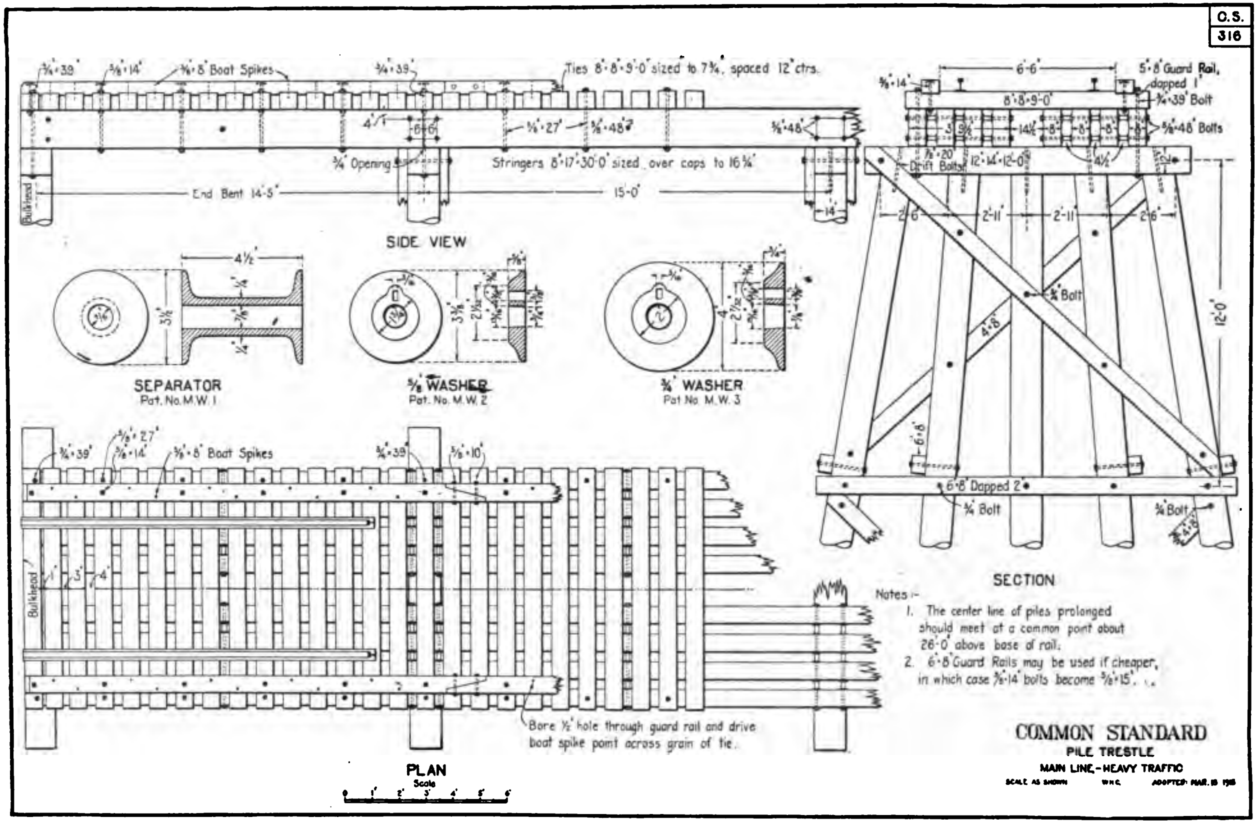


CROSS SECTION OF DECK

SIDE ELEVATION OF DECK

PLAN OF DECK FOR TRESTLE ON TANGENT

Standard Trestle Bridge on Tangents, Louisville & Nashville R. R.



Standard Pile Trestle, Southern Pacific Co.

DISCUSSION.

(Subject No. 2, Pile and Timber Trestle Bridges.)

The President:—This is one of the most important subjects we have for consideration and if it is agreeable we will take up the report by sections rather than carry the whole paper to the end for closure. The first section of this report, referring to ties, is open for discussion.

We have several of the members of the committee present and if they wish to add something to this particular portion of the report we would like to hear from them now.

C. H. Fake:—The report mentions the use of tie plates not having flanges on the bottom. That is all right. There is another question that should be considered and that is the practice of spiking or not spiking the slots in the angle bars. It is my opinion that spiking in the slots of angle bars on bridge ties is equally as injurious as flanges on the tie plates.

G. W. Rear:—Answering Mr. Fake and also continuing the discussion on the subject of ties: Our experience has proven that 8 in. by 8 in. ties have a much greater life than 6 in. by 8 in. ties and also that the smaller tie is not stiff enough to distribute the load equally to all the stringers. Nine feet is our standard length and we see no reason for changing it.

Ties should be sized on two adjacent sides, in a planer, to 7¾ in. by 7¾ in., giving the user a choice of one of four sides to be placed up. The flat grain should be up, as the edge of vertical grain will check or split open, permitting water to enter. The committee is right in regard to tie plates with claws causing ties to decay. We are using flat tie plates with success. The rails should be spiked to every tie. This is especially necessary where tie plates are used. Slots in the angle bars should not be spiked. Anti-creepers should be used instead.

R. H. Reid:—The question was raised of having the ties sized uniformly for their entire length to 7½ in. or some other standard size to avoid the expense of framing over the stringers. I do not think we get the best results with ties sized their full length. The idea of framing the ties is not only to give a uniform bearing for the rail, but also to hold the ties in place on the stringers. Otherwise the ties will shift back and forth across the stringers. Spikes, tie bolts, drift bolts, lag screws and other similar devices are used to hold the ties in line, but they will not do it. Such has been our experience on the New York Central. We have acquired lines, at various times, with that kind of experimental construction on the trestles, and where spikes, drift bolts or lag screws have been driven through the ties into the stringers, they have either worn larger holes in the stringer or the tie, or the ties have become loose and have shifted around. In the same way, in attempting to fasten the guard timbers or guard rails onto the ties by placing undapped timbers and fastening them down with spikes, the spikes will churn loose in the ties or wear loose in the guard rails and will not hold them in place. They are also very ineffective in preventing the bunching of ties in case of a derailment. I had occasion last week to make an inspection of our Kankakee branch, where in many cases the guard timbers are spiked to the ties with a spike through every tie. I found places where the guard timbers were so badly worn that they could be lifted off over the heads of the bolts or spikes. In my opinion they should be bolted to the tie. Our practice is to bolt them through every fourth tie, and that brings the bolt through the joint at the end. I think the ties should be framed down over the stringers to a standard depth. We use 7½ in. framing for an 8 in. tie. Our standard tie on a wooden trestle is 8 in. by 8 in. by 10 ft. long. I don't know of any reason for using a deeper tie except with a considerably wider stringer; if circumstances should demand a stringer 5 course, 9 in. by 18 in. it might be well to use a deeper tie to distribute the load over the entire chord. In the case of tie renewals, it is not so much of a job where the ties are bolted through the guard timbers as where they are fastened with lag screws to the stringer. Where the ribbon is bolted to every fourth tie, you can raise it up, remove the ties and replace them.

J. P. Wood:—There is one objection to having ties sized at the mill, and it is not our practice. As Mr. Rear has said, it is impossible always to get the best side up, unless the ties are sized on two adjacent sides. Our practice has been to look the tie over and frame it according to the grain of the tie, keeping the heart side down as far as possible, to prevent the water from running into any season checks that may occur, thereby starting decay. For that reason I prefer to frame the ties on the ground. I also agree with Mr. Reid that the ties should be dapped to fit the stringers in order to prevent end play in the ties thereby throwing the track out of line.

R. C. Sattley:—I cannot agree with either of the last two speakers. When a new pile bridge is driven the first thing it does when trains are run over it is to go out of line and it is necessary to send a bridge crew almost every week to line it. If the ties are fastened to the stringers, either with bolts or with drift spikes, you can simply pull those spikes (if left projecting a half an inch or so), and line the bridge with very little trouble without pulling any spikes from the rail, and that is the better practice. In my estimation the best tie is an 8 in. by 8 in., sized both ways, which allows a choice of sides when laying it.

A. S. Markley:—I cannot agree with Mr. Wood. We always put the sap side down and the heart side up. The sap will decay, and when it decays, it is likely to catch fire and destroy the bridge. In every case, we put the sap side down regardless of any other condition, not excepting the annular rings.

I fully agree with all who dap ties about one inch tightly onto the stringer as a means of holding the bridge in line. In addition we use corbels under all our stringers. Chucks are secured to the top of the caps on the outside of each stringer to hold the bridge in line. When it is desired to reline the bridge the chucks are removed to allow the stringers to slide on the cap in either direction. A ⅜ in. by 1 in. filler is placed under the chuck next to the corbel for air circulation to prevent decay of the caps. With this method there is no pulling of spikes out of the ties or damage to the stringers and ties by inserting and pulling drift bolts. Where drift bolts are used in either tie or stringer, new drift bolt holes will be necessary. It is not possible that the bridge will be out of line so far that these holes can be used in either of the members without moving one of the members in some direction more than the lining of the bridge requires.

Timber is more or less injured in pulling the drift bolts, particularly if the head is driven down tight on the timber or if there is no head on the drift bolt. The only drift bolts in use in our standard trestles are through the caps into the piles or posts. All other members are bolted with slotted washers to prevent the bolt and nut from turning and a 10d nail is driven in the slot.

I. O. Walker:—Much has been said about holding the tie to the chord or stringer. We use two ¾ in. by 5 in. dowels in every tie, half in the tie and half in the stringer, and we have absolutely no trouble with the ties shifting. We fasten the guard rail to the tie with a ¾ in. by 9 in. lag screw and have had the ties torn to pieces but never bunched. Referring to the question of lining which Mr. Markley has spoken about; we use what we term a line brace casting which forms the lower washer or spacing washer between the stringers. This casting has a lug almost the shape of a hand that reaches down the side of the cap and has four spike holes in it. When we line a bridge, we draw the spikes that hold the casting to the cap, and move the entire bridge. In that way we do not tear up the top of the stringer at all. We tried having the ties sized at the mill with poor success and gave it up. We are carrying out Mr. Reid's plan of sizing or dressing the ties at the structure and using our judgment as to which side should be up.

Speaking of tie plates, I am sorry the committee did not recommend the use of thicker ones. On the N. C. & St. L. we began by using tie plates that proved too thin. I believe the width of the stringer should be increased to 10 in. and the tie plate from ½ in. to 1 in. thick.

R. C. Sattley:—I would like to ask Mr. Walker how he fastens the stringers to the cap?

I. O. Walker:—We made it a practice to place our stringers outside the rail, until we commenced putting on ballast decks, since which time the outside stringer is placed directly under the guard rail. We bolt through the guard rail, the stringer and the tie, using four bolts to each panel. The casting I spoke of goes up between the stringers and also forms the spacing washer, one end dropping down beside the cap. In this way there is a complete anchorage from the cap to the stringer. We call it a line brace casting, for want of a better name. It does hold the bridge in line and we have never had a bridge float away that had one spike in these castings.

The President:—Mr. Meloy, will you give us something on this question of ties?

E. S. Meloy:—I am in favor of the lining spike. We stagger them on alternate ties on the center stringer of the chord, which permits drawing the lining spikes to reline the deck. For ordinary lining of bridges, I think our practice is a very good one. We have had no trouble with it.

G. W. Rear:—It seems unfortunate that I should have to disagree with nearly everybody. An experience of 19 years with over 480,000 lin. ft. of trestle has resulted in a very favorable opinion of the undapped tie. Where every third tie is bolted to the stringers with machine bolts, there is no tendency for undapped ties to shift on the stringers and certainly not so much as for the stringers to shift on the caps, where they are usually fastened with only two bolts.

Track does not go out of line between bents and, in case a trestle goes out of line, it is better to shift the stringers rather than the ties.

R. C. Sattley:—How do you line them?

G. W. Rear:—It is seldom necessary to line them. I believe that a whole lot of the success lies in doing a good job in the first place.

J. P. Wood:—I think if we have good foremen on the job and build good bridges they won't go out of line. That may seem pretty strong, but I can call to mind a number of bridges I constructed that have been in service a good many years and they have never had a spike pulled for relining.

G. W. Rear:—I might say that in our territory we have no frost, and it is possible that some trestles go out of line on account of frost. I used to be connected with a railroad that had a good deal of frost and I was bothered with bridges heaving and going out of line. This may explain why our trestles do not go out of line.

R. C. Sattley:—In driving piles one often has to drive them through gravel and large boulders. In the country where I have maintained bridges it has been necessary to jack the piles into line and in proper position to fit the cap. As soon as trains start running on such a bridge, it will go out of line and will have to be relined.

R. H. Reid:—Along the line of this discussion, as I mentioned a few minutes ago, I went over 200 miles of our Kankakee branch last week where in many cases the ties are laid flat on the stringers without being dapped, and are spiked to the stringer. In many cases the ribbons were spiked to the ties. Probably three quarters of the bridges on that line needed relining. On our main line, where we have the ties framed to the stringers and the ribbons framed down over the ties, there is not one bridge in fifty that needs lining. We have miles and miles of bridges on the old Lake Shore, very few of which need relining, and we drive through some pretty rocky soil, boulders of all kinds, gravel, quicksand, old timbers and everything else. We draw the piles in a little closer at the top in framing them, but don't draw them so far that they will pull out when we put trains over them. We drive them down solid, put the caps on, bolt the caps on the decks, and those bridges stay in line; we seldom have to reline them after that. We had trestles across Sandusky bay where, through the crowding of ice fields in winter, the bridges have been crowded from 10 to 12 in. out of line in the middle, but as soon as the ice is removed, they go back into line and stay there. These bridges range from 300 to 850 ft. long. That is pretty good evidence that the bridges will stay where you put them if properly built.

J. B. Sheldon:—I think the general engineering practice is to size the ties to an even thickness and use plug-bolts or spikes for the fastenings. I am glad to hear such a careful and experienced maintenance man as Mr. Reid advocate the gaining of ties. My experience, after using plug-bolted and gained ties, is that the gained tie is the better. The only advantage I have found in plug-bolted or spiked ties is that they are cheaper. We sometimes use this method on temporary work, but when we want a good job we gain the ties. Our stringers are held in line by chucks fastened to the caps. These are either of wood or angle iron, using coach screws in the angle to fasten to the caps. In relining bridges we remove the fastenings in the chucks and then line the stringers. When only a slight movement is necessary the track spikes are withdrawn, the rails lined and the spikes redriven.

A. S. Markley:—If the ties are dapped tight on the stringers and properly spiked, there is no danger of steel kinking out of line on account of heat. If only drift-bolted to the stringer or through the joint between them, it will get out of line, or kink, so much so that the track will ride rough and look bad.

F. E. Schall:—We dap our ties from 8 in. to 7½ in. for trestles and spike every third tie to the stringers. This is considered good construction for proper maintenance. Southern railroads can no doubt purchase planed ties more cheaply. We find that planed ties season-check more freely than rough sawed ties. Sawed timber does not conform to exact dimensions and therefore requires framing, or dapping. Dapped ties lend more side stiffness to the floor and make a safer structure. I wish to put myself on record as favoring the dapped ties.

J. N. Penwell:—It has been mentioned by several here that bridges go out of line after they are driven. It is true they do, but they don't go out of line between the bents. They go out of line immediately over the bents. The only cause for a track going out of alinement between the bents is the springing of the stringers. If we have a bridge in perfect line to begin with and it goes out of line on account of heaving of the piles, we move the stringers back over the cap and again have a perfect line over the bridge. I think that in the maintenance of a bridge the extra cost of the cap is more than offset by the lessened cost of changing the stringers and the ties. If you want to line a bridge where the ties have been spiked into the stringers ⅛ in., ¼ in. or ⅜ in., I don't see how it can be done except by pulling the bolts out and driving them in entirely new places. I do not like a dressed tie but prefer to have it rough, as it will last longer and seems to be better timber. If it is dressed at all, it should be dressed on all sides in order that any side may be selected for the top. A tie dressed on two sides only does not properly permit this choice. When this subject was up a few years ago I advocated a dapped tie, at which time some of the men said that I was 20 years out of date. I notice, however, they are still at it. I am heartily in favor of the dapped tie; but I don't like to place it in a way that will make other repairs too expensive.

J. E. Toohey:—We are using a dapped tie altogether. To overcome the expense of dapping by hand I invented a machine which we are using with excellent results. It is cheap, easily operated and anyone can make a first class job with it. Two men will dap 100 ties a day with it.

W. E. Alexander:—I did not know there was so much difference of opinion about bridge ties, but I can see that there is reason for it. It is seldom that a bridge can go out of line without going out of surface. I do not see how one can line a bridge without moving the ties and surfacing. I am from a timber country and we have a good many trestle bridges. Our form of trestle bridge is different from any shown in this report. We use a longer tie and what we call a jack stringer, further out than the track stringer. The tie is faced and sized on the ground as Mr. Reid spoke of, and I have always approved of it. As far as I know we have never had trouble with a bridge going out of line unless it went out of surface, and when one comes to line a bridge that has gone out of surface he must move the stringers.

One of the members spoke of smooth tie plates on a bridge never moving. We use hard pine ties and we usually do not use tie plates on bridge ties where the bridge is straight. Where we do use tie plates we use the Goldie and we have never had ties give out because of the type of plate. The reason he finds the smooth tie plate better than we do is because we have a great deal of frost and moisture that makes the tie icy. Where they do not have these conditions, it is not so hard for the spike to hold the track in place as it is if it is frosty under the tie plate. A smooth tie plate under a rail is a poor thing in our country on account of the frost.

We have found that our bridges go out of line mostly in deep mud where piles are supposed to be driven equally to bottom but the foundation is different. When the load comes on them they go down, and when they sink out of level the bridge goes out of line. We have to surface them by jacking the stringer on the cap and shimming them and then jacking the stringer in line. We have to spike the rail to line a little at first, but when we come to make repairs we line the stringer under the rail. It seems to be a reasonable thing to do. Of course different conditions call for different treatment.

J. E. Cole:—I would like to ask the members what they would do if they had bridges that go out of line one way one day and the other way the next day. Along Lake Champlain we have this condition. I am personally very much in favor of dapped ties. In find that by dapping them and bracing the bridge well we have no trouble. We have a member with us, Mr. Flint, who has had bridges go out of line from one to four feet. I would like to hear from him.

C. F. Flint:—The bridge on Lake Champlain which Mr. Cole referred to is nearly a mile long and has 8-in. ties line-spiked on the stringers. We are obliged to move the track first one way and then the other during the winter. I don't know of any other way that we could do it than to spike the ties to the stringers.

F. J. Conn:—We have a little road down in Kentucky, on which I believe we have some very good standards for wooden decks. We use an 8 in. by 10 in. tie which we size. In addition, they come from the mill dressed and we treat them with wood preserver. On our latest decks we use a tie plate 31¼ in. long which passes under the inner guard rail as well as the main rail.

Our inner guard rail is an 85 lb. rail, the same as the main rail. Those rails are now held in place with screw spikes and every tie has a ⅝ in. bolt through the guard rail. I am in favor of sizing all ties, even if they come dressed. One member said he thought they lasted better without being dressed, but I do not agree with him. Some of you know that years ago when we used to get hewed timber it lasted for years and years,—sometimes 20 years. I have taken it out of the Illinois Central after it had been in 22 years, but I do not believe that sawed timber will last that long. We are now using none but treated ties.

J. N. Penwell:—For the information of those not acquainted with the Cincinnati, Hamilton and Dayton, I would like to say that they have a unique manner of framing ties. They always dap the ties and never dap their stringers. Their stringers are full size. They avoid any damage to the stringer by framing. They take the dimensions of the stringer for each tie and frame it to these dimensions and thus provide easy and ample means for lining bridges on the cap. I never saw a C. H. & D. bridge out of line. In regard to the depth of the tie, I do not see why there should be any question as to their proper depth. We have bridge engineers who figure the proper depth of the tie to distribute the load properly over the stringers. A 6-in. tie will carry a track safely, so far as the tie itself is concerned, but the weight must be distributed properly over the stringer, taking into consideration its width. I understand that the general practice now is to use an 8 in. tie. I presume that has been worked out in detail by the engineers.

The President:—We would like to hear from Mr. Killam.

A. E. Killam:—We have no pile bridges.

C. H. Fake:—To get the sense of this convention, I move that the sizing of the tie, lining it, etc., as recommended by the committee, be adopted. I understand that the committee recommends that the tie be sized and secured to the stringer by some form of line spike, lug or bolt.

The President:—As I understand it, the whole report is in the nature of a suggestion rather than a recommendation. The committee does not mean to lay down hard and fast practice, but the report purports to be an opinion of the practice that is being followed. It would hardly be necessary to offer a resolution to adopt any particular method outlined in the report. The report is for information, and not to establish recommended practice. That has not been the custom in our association.

C. H. Fake:—I thought that would be a good way to get the sense of the convention.

The President:—Adopting recommended practice is something we have never done.

A. S. Markley:—We can only recommend from our own standpoint. If we should adopt that by a rising vote, we would still continue doing as we have been.

P. J. O'Neill:—We can accept it as a recommendation if the majority see fit, but it seems to me that to accept a small part of a report of this committee and not the balance, would be to adopt that portion as a recommendation of this association and to reject the rest of their report. I believe that the report ought to be accepted as a whole, not piece meal.

W. E. Alexander:—On our trestle bridges the ties are 13 ft. long. Our standard floor has two wood guards outside of each rail, one 5 in. x 8 in., about 12 in. outside of the rail, and one 8 in. x 8 in. near the end of the ties, each dapped down on the ties 1 in. and bolted to every third or fourth tie.

We have a steel viaduct with two 100-ft. steel deck trusses about the center of the bridge, where at one time a derailed car of logs went across the bridge with the forward truck thrown around so that one wheel was dragged on the ties about half way between the rails scarring every tie on the bridge. Many of the 8 in. x 8 in. ties on the truss spans were broken in the center between the I-beams, which were inside of the rails. The top chords being the outside support,—the outer guard rails held the ties at right angles to the track so the gage was not altered and the floor was safe for trains, although all the ties had to be replaced in making repairs. I think if there had been 3 inside guard rails on the bridge at that time no damage would have been done to the ties. After that, when on a trip to one of our conventions, I saw some bridges with 3 inside guard rails with each end of all three turned down over a tie into the ballast. On my return I recommended this and I was allowed to put them on some of our most important steel bridges. Soon after these were put on we had a similar derailment where the trucks skidded the whole length of the bridge but no harm was done to the bridge floor. Some thought the center rail was unnecessary, and when renewing the bridge floors we left the center rail off, putting on two inside guard rails which came together to a point in the center some distance from the ends of the bridge. About a month after we had renewed one bridge floor in this manner we had a set of trucks go over the bridge in the same position as before described and, while it did not wreck the bridge floor, it damaged the ties to such an extent that they all had to be replaced.

While we still have the 3 inside guard rails on some of our bridges it has become our standard to put on only two which are placed 13 in. inside of the running rails and clear the flangers when they are down for working in snow. These rails come to a point in the center of the track at varied distances from the ends of the bridges as circumstances require. I approve of 3 inside guard rails having the ends of each rail bent down over a tie into the ballast, as it is more likely to carry derailed trucks across a bridge, whereas, a center point may cause the derailed car to be thrown over to one side far enough to strike a through truss or go off the fill entirely.

G. W. Rear:—The matter of guard rails and guard timbering of a bridge requires a good deal of thought. The guard-timber is used to maintain the proper spacing of the ties and at present the majority of the railroads dap the timber about one inch. However, this is expensive and the daps split off easily. Some roads are now using an undapped timber. I believe the dapped guard timber will soon become obsolete along with the dapped tie, especially where creosoted material is used, but I do not believe that spikes, bolts or lag-screws are sufficient to hold ties in their proper position when derailments occur. I favor the use of wooden spacing blocks, spiked on the side of the tie. These can be made of 4 in. by 4 in. timber cut a little shorter than the depth of the tie. They should be placed outside the rail, probably under the guard timber. With this type of deck, no guard timber is necessary, but its use will probably be continued for the sake of appearance.

Needless to say, the guard timber should be placed far enough from the running rail that derailed wheels will strike the inner guard rail (if any) before touching the guard timber. Wheels coming against the inner guard rail tend to straighten while those coming against the outer guard timber tend to slew.

Inside guard rails should be applied to all trestles of any great height or length. Few roads can expect to get them on all trestles and their use is generally confined to the longer and higher structures. However, as time goes on their use will become more general.

The inner guard rail should be placed at least 8 in. from the running rail, so that derailed wheels will have room to pass through without wedging. They should be well braced with rail braces, especially near the ends where they are drawn in to the center of the track.

Three rails, spaced about equally between the running rails, are used to some extent,—the claim being that derailed cars may be off the track far enough to miss the guard rail point and be thrown farther off than before,—but the wheels of such cars are off the ends of the ties and there is little hope of straightening them.

The guard rail is most effective in guiding wheels which have become derailed before reaching the trestle and are not too far off, or too badly slewed. Trucks that are badly slewed usually wreck the train before going very far.

Guard rails, with re-railers, are used with great success, but as their use is not general in connection with trestles, discussion of them is probably out of place. The Southern Pacific has been using them since 1874 and uses them on all through bridges and on high viaducts and trestles, especially on curves. Their efficiency has been proven a number of times.

The end of the guard rail should extend about 50 ft. beyond the end of the trestle, so that derailed trucks will have a chance to line up or be wrecked before reaching the trestle.

H. Rettinghouse:—Mr. Rear remarked that the dapping of guard rail timbers was a thing of the past. I presume he had reference to the Southern Pacific. I don't think that many railroads have abandoned the idea of dapping guard rails. It is not many years ago that the Chicago & Northwestern used a guard rail without dapping. It proved a matter of mistaken economy. I well remember that one of the first bridges built according to the new standard with an undapped guard rail was built under my charge. It was but two weeks afterwards that we had a bad derailment and every one of the ties bunched up. That was the end for me, of guard rails without dapping. I realize that some care is necessary and I realize also that a guard rail dapped too deep is perhaps detrimental in so far as the life of the ties is concerned, but a moderately dapped guard rail is certainly preferable to one without dapping.

F. E. Schall:—I agree with Mr. Rear that the steel guard rails should be spaced 8 in. from the main rails, this to be the distance between the heads of rails, and I also agree with him about the length of steel guard rails. We have had some very convincing experiences as to the effectiveness of such guard rails. Our standard provides that guard rails extend 60 ft. beyond the receiving ends of bridges on straight track, and 200 ft. at important bridges of long span, or where local conditions require it. In some cases on curves the guard rails extend 400 to 500 ft. beyond the receiving end of the bridges.

We dap our 6 in. x 8 in. guard timbers to 4½ in. over ties, so that the top of the guard timber does not project above the rails of tracks. The shoulders of dapped guard timbers are nailed with steel nails to prevent their splitting off. In my opinion a dapped guard timber will do more to prevent ties from bunching than any other method. The use of lag screws will probably cost just as much as the dapping, but even if it were cheaper it would not be as efficient.

The safety of the structure is of first importance and all cheaper methods should be carefully considered from this standpoint before being adopted.

I. O. Walker:—We have not had a guard rail since we commenced buying creosoted ties, but I want to call your attention to the fact that we hold our ties by a dowel into the stringer. We have found nothing equal to it. We are also using the re-railer, we think, with great advantage. Our experience has not been as broad as that of the Southern Pacific but it has been equally successful. The question of holding the ties is connected incidentally with the guard rails on I-beam girders and others—we use two castings per tie on the ends of ¾ in. bolts that go under and clasp the top member of the girder or the top of the I-beam. They are securely held by ¾ in. bolts. By using the ordinary guard rail and lag screws we have had no trouble with ties bunching.

G. W. Rear:—Mr. Rettinghouse made a mistake in thinking that the Southern Pacific was not dapping its guard timbers. It is,—but I think the tendency is to quit. Some members here remember the accident at St. George on the Grand Trunk in 1880. There was a very bad derailment caused by the tire coming off the driver of the locomotive where the ties bunched on a bridge and the train went through, killing 75 or 80 people. Directly after that they commenced using a spacing block between the ties consisting of a 4 in. by 4 in. piece of timber standing on its end between each tie, placed about 6 in. outside of the rail. They still dapped the guard timber and probably do yet. The weak part of the spacing block is that it is not under the guard timber, where it will be protected from the wet and not retain moisture to cause decay. That will certainly cost more than it would to dap the guard rail, but it is infinitely better because the spacing block is of the same depth as the tie. It is nailed on the tie as each tie is placed, usually before the tie is brought to the bridge, and being the full depth of the tie there is no possibility of the ties bunching. While this requires more timber, there is a little less labor. The arguments of engineers have been towards doing away largely with the dapping of the guard timbers, and attaching them only with lag screws. I believe that is a weak point, but with the addition of the spacing block, an undapped guard timber is far better than anything we have now, and while not quite as cheap, it makes a much better job. I am not advocating the undapped guard timber, but the spacing block.

A. E. Killam:—On the Intercolonial Ry. they have abandoned the wooden guard rail entirely, which was a move in the right direction. This makes the decks on through and deck bridges or steel bridges the same in principle as the decks on trestle bridges. The ties on all of our through and deck bridges are 8 in. by 10 in. or 7 in. by 12 in. according to the nature of the girders. Blocks 4 in. by 6 in. from 10 to 12 in. long are put between the ties and spiked through the ties as the deck is laid. The ties are all framed to exact dimensions before they are taken out on the bridge and they are held in position by anchor bolts, with a turn on the end over the flange of the girder underneath and up through the ties with screw bolts about every third or fourth tie. In that way the ties cannot bunch. I have discovered numbers of places in going over the road where a car has been off the track and in some cases an engine has run over the bridge and never disturbed the deck in any way more than to leave the marks of the flange on the ties. In some cases we put the guard rails outside and in some cases inside. In most cases the ends go down to a large boiler plate in the ground underneath the ties, so that we have seldom ever had a derailment on the bridge but that it went over safely. We have never had a wreck on a bridge. As Mr. Rear has said, there is no doubt that spacing blocks tend to rot the ties. We have adopted a system of putting a 4 in. by 4 in. block under the rail instead of under the guard rail, so that the rail protects the block. I have never seen one of them rot yet. The outside guard rail is spiked down to the ties as is also the inner guard rail. Ten inches is the regular spacing of the guard rail from the running rail,—whether inside or outside. We secured the best of engineering skill in determining that point. In some cases we have three rails, but the center rail is considered useless except for one purpose. There are so many things that occur to derail a train of cars on the road, that it is hard to guard against them all. The third or center rail is to protect the bridge so that in case a car breaks away as it comes on to the bridge it cannot gradually work its way across the track. With this system of guard rails we have no difficulty with cars or engines off the track on bridges.

The President:—We will have to close this portion of the discussion on guard rails and go on to bridge stringers. If there is anything to be said on that section, we will have to concentrate and make our remarks as brief as we can and to the point, because this is a long report and there are a number of other reports to consider this morning.

G. W. Rear:—It does not seem as though there was much to say on the subject of bridge stringers in addition to what is in the report. The length of the panels in trestles depends on the available sizes of stringers and on the live load carried. As 16 to 18 in. is about as deep as it is advisable to order stringers, the panel length cannot be greater than 15 ft. where the live load is equal to Cooper's E-55 or greater. Stringers should not be sized to width and it is not advisable to plane them to depth in the saw mill. Such sizing not only reduces the area at the center of the span, but as the sizing would be done on material direct from the saw, the shrinkage would be unequal and when seasoned the depth would be less at the ends of the stick than in the center and it would be necessary to size it again.

Stringers should be fastened to the caps with machine bolts. We prefer to have the nuts up, with slotted washers and the nuts properly secured with nails; few nuts come off and nuts on top are easier to inspect.

R. H. Reid:—The question of stringers is probably the most important one in trestle construction. As Mr. Markley says, it is desirable to keep the width of the stringers as narrow as possible, not only to get piles in, but to concentrate the bearing under the ties. The narrower the stringers the less danger there is of sparks dropping on them and setting fire to the bridge. So far as keeping the number down to three course, it would be preferable to keep them down to two course if it were practicable to do it, but on roads that have even moderately heavy motive power and cars it is impracticable to keep the stringers down to less than three for panels that are generally considered practicable. On the New York Central we have been using three course, 9 in. by 18 in. stringers for 15 ft. panels as a standard trestle. We are now considering cutting down our panel lengths to 12 ft. or 13 ft. on account of the heavy motive power, and using either a three course chord 9 in. by 18 in., or, if we can get timber which will stand the higher stresses, cut it down to three course 8 in. by 16 in. stringers. That has not yet been decided. There is an advantage in obtaining small stringers because they are usually cut from younger trees and better timber. As a rule, I think the 8 in. by 16 in. stringers will last longer than the 9 in. by 18 in. timber because the timber is closer grained and finer and seems to have longer life in it. In regard to getting the piles in place in a trestle without moving the stringers—that can probably be done with ordinary three-course stringers where the depth is high enough so that the pile can be driven outside the stringers and drawn in properly under the rail. On low trestles one cannot draw the piles in very far. On the New York Central, where we have the wide stringers, we move the stringers where necessary, in order to get the piles in right.

L. Jutton:—On the 4th page of the report the committee refers to objections to using drift bolts in stringers on account of the difficulty of drawing them out, and rather recommends that a bolt be put entirely through the stringer and cap. I question the necessity of going to the trouble of putting a bolt entirely through the stringer and cap, and if there is less difficulty—and I agree that there is—in getting an ordinary drift bolt through after being placed, it will be best to use a drift bolt with a square head on it and leaving it up where one can get hold of it.

R. H. Reid:—We have had experience with both forms and in nearly every case where we have had drift bolts driven properly into oak, it has been very difficult to pull them. We have had drift bolts driven through the stringers into the cap, where the heads would pull off and the bolts would break in two before they would pull out of the timber. Our standard is for a nut and bolt, with holes for the bolt 1-16 in. large so that the bolt can be removed more easily. If a bent is crowding hard on the bolt, sometimes it binds and pulls pretty hard, but if drift bolts are driven in a tight hole or if, as in case of oak timber, they have been in any length of time, they will be found rusted in so fast that it is almost impossible to pull them.

F. C. Baluss:—Only one standard for pile bridges is in use on the Duluth, Missabe & Northern on main lines and spurs. Six-pile bents are driven and capped with 12 in. by 14 in. by 14 ft. timbers. The span consists of six 9 in. by 16 in. and two 6 in. by 16 in. stringers with 6 in. by 8 in. by 12 ft. ties spaced 12 in. centers. This length of ties is longer than used by many roads, but it has been found to fit the peculiar demands of our service better than shorter ties. The timber guard rail consists of 8 in. by 10 in. timbers dapped on the ties and bolted through every fifth tie, the bolts extending through the jack stringers. The ties are not dapped over the stringers but they are fastened by spiking alternate ties to the chords.

Native tamarack piling and western fir timber are used in construction, the life of the bridges being about ten years. The present policy of this company is to replace them with permanent bridges as they require renewal.

A general inspection is made by the bridge engineer twice each year, in the fall and again in the spring about a month before the ore traffic commences. Other inspections are made frequently by the division bridge and building foremen. Repairs are made during the winter as far as possible. No treated timber has been used by this company.

S. C. Tanner:—The standard plan of the Baltimore & Ohio provides for drift bolts in caps. Where corbels are used, the drift bolt is driven through the corbel into the cap and the stringer is bolted to the corbel. We consider that this is the best way to fasten stringers to make them absolutely safe. The holes for the bolts are bored 1-16 in. larger than the bolt, which permits their easy removal. That is about all the standard we have, and I see no reason for changing it. We consider this the best method.

The President:—This subject is productive of so much discussion that we cannot carry it through item by item, and it may be necessary to have an extra session to take care of it. We will have to pass on so that we can go through some of the other papers. I would suggest that there be some informal discussion of the various points that have been brought out by this paper.

J. P. Wood:—I must say that I disagree with the committee on a 12 in. by 14 in. cap. With the ordinary piling that we get today it is absolutely impossible to get piling for a bridge of any size more than 12 in. in diameter at the quarter point, and when you place the 14 in. side of a cap on these piles you will find in a few years that the sap wood is rotted and there is a tendency for the pile to crush into the cap, more-so than if the cap is set on edge and the pile covers the full width of the cap. That has been my observation and experience and I believe it is the same with all roads in this part of the country,

G. W. Rear:—Caps for pile trestles should be 12 in. by 14 in. on flat and for framed trestles 12 in. by 14 in. on edge. The cap is placed on the flat in pile trestles on account of the varying size of the piles, it being desirable to get as much bearing on the piles as their size will permit. Piles being round have less bearing than posts which are square. Twelve feet is long enough for caps in open deck trestles.

With modern power, 5 piles per bent are necessary and with good driving they will support all the load that can be put on them. With Cooper's E-55 loading and 15-ft. spans the load per pile is about 16 tons, which is conservative.

The center pile should be driven plumb and. all the others battered, being driven with such batter that all piles in a bent will meet at a point about 25 ft. above the deck. Trestles so driven and properly braced will not go out of line.

It is impossible to drive 4 or 5 pile bents without disturbing the stringers and get any kind of a job. Attempts to do so result in very shabby and ragged work.

We prefer a 4 in. by 8 in. brace to the usual 3 in. by 10 in. especially for creosoted pile bents, as it is often necessary to dap the brace to fit the piles. Where one bolt is used at each intersection the 4 in. by 8 in. brace has greater bearing on the bolt, which is the limiting feature in the value of the brace.

Longitudinal girts should be 6 in. by 8 in. at least. Longitudinal braces should be 8 in. by 12 in. where 2 braces are used, and 6 in. by 10 in. where 4 braces are used.

Ballast deck trestles, properly constructed, may well be classed among permanent structures, as they will have a life of 30 years or more. They are fire-proof from above, are easy riding, and require very little attention—in fact, no attention at all, for a great many years. They should be at least 15 ft. wide and constructed of creosoted material throughout, excepting, possibly the bracing, which naturally has a long life and is replaced cheaply. One reason for not treating the braces is on account of the framing that is necessary in applying them.

Ballast decks of untreated timber protected by built up roofing have been used extensively, but experience proves them to be of short life in anything but an arid country. They cannot be kept from leaking, due largely to the roofing being torn when lining the track. Eight inches of ballast under the tie is about right, and is enough for those roads using more on embankments, as it rests on a firm, well drained surface.

The best deck for standard roads consists of 12 stringers about equally spaced. Extra stringers are required on account of the weight of the ballast, which is about 1,600 lb. per ft. of trestle, or about 1-3 of the live load.

An experience of 19 years with about 225,000 lineal feet of ballast deck trestle does not show any advantage in running the stringers across the cap and lapping joints. Such a method does not lend itself to neatness, which is a feature that should not be neglected, and is a waste of 14 in. of stringer. There is no advantage in using roofing to cover creosoted stringers and plank.

A trestle properly designed is without doubt the most economical structure that can be built. The principal reasons for replacing them with permanent structures are liability to fire or other damage, and the unsuitability of a trestle to pass large quantities of water—especially where there is any drift. At a little distance the resemblance of a trestle to a fine-toothed comb is very noticeable. Of course where all the waterways are of permanent construction, operating expenses are less and the burden is placed on the fixed charges. This may have some influence in determining the railway company's policy.

E. E. R. Tratman:—The committee suggests the use of a layer of composition roofing upon the floor of a ballasted-deck trestle, but many railways dispense with this and consider it unnecessary. In regard to the trestle accident on the Grand Trunk Ry. in 1889, mentioned by one of the members; the accident was due largely to the absence of inside guard rails, reliance being placed solely on guard timbers along the ends of the ties, which are in poor position to stop derailed wheels. The bunching of the ties resulted partly from insufficient fastening of the guard timbers and partly from the wide spacing of the ties, which were said to have been at least 8 in. apart in the clear or 16 to 18 in. center to center. Such wide spacing allows the derailed wheels to drop far enough to give a decided horizontal thrust against the ties, while with closely spaced ties the horizontal thrust will be very much less. Inside guard rails should be considered as indispensable on all bridges. It is rather strange to note the very limited use of derailing devices at the entrance to high bridges. Another strange development is that the flaring extension of the guard timbers beyond the end of the bridge, to catch derailed cars and guide them onto the bridge, has almost entirely disappeared, although at one time it was a general feature of bridge floor construction.

A. B. McVay:—It is difficult to separate, in this discussion, guard rails from guard timbers, girder and truss bridge floors from open deck and ballast deck trestles, but all the remarks are instructive.

It will be noticed the committee words its suggestion this way:

> " Regardless of all that has been said and written with reference to the dapped guard timber, no more effective means of holding the ties in place has yet been perfected."

I think very few roads, according to my observation, have gotten away from dapped guard timbers, but we do believe that a move in that direction is a good one, and think it is coming. Metal spacing blocks of any kind are probably expensive. I do not think gray iron castings will answer the purpose, but think the blocks should be of steel or malleable castings, the latter being the more expensive. I agree with Mr. Rettinghouse that if metal spacing blocks of any kind are used, they should be placed under the guard timber. Some of the roads use guard timbers on inside of running rails on all floors. Practically all roads use these inside guard timbers on girder and truss bridges. On the road that I am with, no inside wood guard timbers are used on open deck or ballast deck trestles; but on all girder and truss bridges we use outside guard timbers, about 5 in. x 10 in. dapped to 4 in. in thickness over ties, spacing these about 10 in. outside of the running rails, fastening with ¾ in. by 8 in. lag screws. For inside guard timbers on such bridge floors, we use 4 in. by 10 in. dapped to 3 in. in thickness over the ties, spacing them about 3 in. from the running rails, and fastening with ¾ in. by 7 in. lag screws. This practice has proven satisfactory. Something depends on the kind of timber used, as to whether or not bolts or lag screws are the best fastenings for guard timbers.

The use of re-railing castings on the Louisville & Nashville probably dates back as far as their use on the Southern Pacific. These re-railing castings are, however, not used at the ends of all bridges or trestles, and the devices used on the L. & N. are somewhat expensive. I adhere to the belief that guard rails ought to be applied to all bridge and trestle floors. If applied along the lines suggested in this report, they would probably take the place of the re-railing castings formerly used and prove effectual and somewhat cheaper. If guard rails are used in connection with re-railing castings, of a type similar to the L. & N. standard, the guard rails should be spaced about 3 in. from the running rails. We have records of numerous instances where the re-railing castings have re-railed cars. My attention was called to one such instance only a short time before coming to this meeting. A derailed car in a train approaching a bridge, was re-railed by the re-railer frogs, causing little or no damage. This occurred without the knowledge of the train crew. If the re-railer had not been in place much damage would probably have been done to the bridge floor. I do not favor inside wood guard timbers on any bridge or trestle floor, and think that ultimately guard rails, spaced at the same distance from the running rails, will supplant inside wood guard timbers. Mr. Rear's suggestion that a distance of 30 ft. from ends of bridges is too near to bring points together, is no doubt good. We did not consider the question of space between the guard rails and the running rails, thinking that could be better left to local use or judgment.

It is my suggestion that if guard rails are spaced 8 in. from the running rails, that the outside guard timbers be spaced about 10 in. from the running rails. In all trestle and bridge construction, attention must be given to economy. Something has been said in regard to omitting guard rails from ballasted deck trestles, but I do not think this should be done if in general practice they are used elsewhere.

Mr. Sattley suggests 16 in. of ballast under the ties on ballast deck trestles. I assume the gentleman has had only slight experience with ballast deck trestles. Difficulty will be encountered with curb timbers of sufficient height and strength to retain that amount of ballast on decks of usual width. Line and surface will be unnecessarily hard to maintain, at least where broken rock ballast is used. Slag ballast being sharper might possibly obviate difficulties that would be encountered using an excessive amount of broken rock. It will also be necessary to increase considerably the amount of timber in stringers to carry the additional load. An important detail in ballast deck trestles is to get sufficient timber properly distributed under the load.

The tie plate was the first feature of this discussion. I am glad that our suggestions are so ably supported. Personally I have always preferred smooth bottom tie plates for use on all bridge floors, believing as I do that tie plates either smooth or with slight corrugations, especially for bridge floors, would conserve all requirements of the tie plate and avoid the disadvantages of the claw plate. It is difficult to imagine a more destructive agency than the claws of the plates penetrating the surface of the ties. This is especially detrimental to the life of the timber in a damp climate and with the kinds of wood most generally available. It is generally conceded that lateral thrusts against rails are slight and there seems to be no good reason for claws on tie plates.

As to surfacing ties in the manner suggested in the report, I agree with Mr. Rear that it would probably be better to size ties on two adjacent sides, thus permitting any one of the four sides to be placed up. I do not agree with the suggestion that dressed ties are less durable than rough timber and there is nothing in my experience to support such a theory. One argument in favor of ties of square section is to allow a choice of the proper side to be placed up. I am surprised that Mr. Markley adheres to framing ties with the heart side up and am quite sure the general practice is to place the sap edges up. However, 8 in. by 8 in. ties should be furnished free of sap wood.

The discussion on dapping or gaining indicates some confusion in the meaning of these terms. The L. & N. practice for many years has been to gain bottom sides of ties to uniform thickness, boring ⅝ in. diam. holes in each end of the bottom of the tie, driving into these holes ¾ in. by 5½ in. round dowels projecting about 2 in. below the surface, and spacing them so that they will drop in the spaces between the stringers. The stringers are put together with separating washers ¾ in. thick. This practice takes care of the line, and has proven effectual. We have used bolsters or corbels on caps under the stringers, each bolster bolted with two ¾ in. vertical bolts through the tie, stringer and bolster, and one vertical anchor bolt through the tie, stringer, bolster and cap, with nuts and washers underneath.

If piles are properly driven and braces properly placed, there is little likelihood that trestles will go out of line, and it will usually be found that line is lost immediately over the bearing on the bent. This can be corrected by removing the anchor bolts, lining and re-boring through the caps for anchors. The L. & N., within my territory, has adopted treated timber ballast deck trestles for all purposes except temporary use.

I may say in conclusion that all matter in this report is offered as suggestions and intended only as such.

SUBJECT No. 3.

RAILWAY WATER TANKS.

REPORT OF COMMITTEE.

Tanks now in use and adapted for use in railway water service comprise practically every type of tank constructed. Therefore a general study of railway water tanks means a study of all tanks.

In preparing this report there was a question as to just what tanks should be given consideration. The decision reached was that the committee could best serve its purpose by confining the discussion to water tanks used in one class of service; namely, those used for locomotive water supply. The reports on concrete tanks in the proceedings of 1911 and 1912 are of such recent date and cover the subject in such a thorough manner that it is felt little could be added at this time. This report will, therefore, be confined as closely as possible to the various types of wood and steel tanks used in railway water service for roadside and storage supply for locomotives.

The purpose of a water tank is twofold—to provide storage for a volume of water that will be adequate for all requirements and to furnish a head or pressure sufficient to deliver the water in adequate quantity at the points required. Upon these two points depend the size and capacity of tanks and the height of the tower. The amount of storage will be determined by the demand and the facilities for supplying water to the tank. For example, if the delivery to the tank is constant, as from a city supply, and the demand fairly uniform, the size of tank may be nominal, but if the delivery or demand is irregular, the capacity of the tank should be great enough to carry over the periods when water is not being delivered to it, and to take care of the maximum consumption. Where a pumping station is maintained and the pumps and pipe lines are large enough to supply the required amount of water by pumping only during the day, sufficient storage should be provided to carry through the night, eliminating the expense of a night pumper. The saving thus effected will often represent a very good rate of interest on the expenditure for a larger tank. Also an increased storage capacity is, to a certain extent a protection against a possible shortage of water on account of breakdowns, as it will frequently allow ample time to make repairs without running out of water, where a smaller tank would cause delays or expense of running for water.

Up to within the past few years, the standard tanks rarely exceed 50,000 or 60,000 gal., while the standard roadside tanks on many lines today include tanks holding 100,000 to 150,000 gal. One railroad recently constructed a 200,000 gal. steel tank for supplying road locomotives. (This tank is understood to be the largest roadside railway water tank ever constructed.) While the tendency of the railroads within the past few years has been to erect tanks of greater capacity, the development along this line has been all too slow and the efficiency of the water service is impaired in many cases to a great extent by small tanks. Particularly is this true at terminals, where a large number of engines take water in a limited time, and at roadside stations where it is necessary to employ night pumpers, thus materially increasing the cost of water. It is not economy to erect a tank good for a life of 30 or 40 years and then find within a few years that it is too small to supply the demand for water without continuous pumping.

There may be instances where it would be preferable to construct two or more smaller tanks rather than one large one, as at terminals, where the water used for locomotives is sometimes of a better quality than the water used for washing boilers and other purposes. The Chicago & Northwestern Ry. has at Proviso, Ill., three steel tanks built close together. Two of the tanks are used for storage of soft water for locomotives, and the third for storage of hard water used for boiler washing and sanitary purposes.

The construction of large permanent tanks has been handicapped to some extent by the fact that, where tanks were located adjacent to tracks the uncertainty of track changes and other construction features often prevented the selection of permanent locations. The result is that many of the tanks constructed are more or less temporary structures. By installing penstocks it is possible to select a permanent location that will not be affected by future construction changes. It is now the practice on many roads to erect the tanks remote from the tracks and deliver water through penstocks. In addition to permitting a more satisfactory location of a tank there are many other arguments in favor of this practice in preference to taking water direct from the tank.

First: A penstock does not obstruct the view as does the tank.

Second: A properly installed penstock offers better drainage and gives less trouble from soft track during summer, and from ice during winter months.

Third: A penstock is less liable to strike trainmen and cars than a tank spout suspended over a track.

Fourth: A penstock does not cause the trouble from freezing that the gooseneck and valves of ordinary tank fixtures do.

The height of the tower or frame of the tank will be determined by the size of the outlet pipe. A 12-in. penstock with a 14-in. main will deliver 4,000 gal. per minute with approximately the same loss of head as a 10-in. penstock with a 12-in. main delivering 2,750 gal. per minute, or an 8-in. penstock with a 10-in. main delivering 1,750 gal. per minute.

The standard height of tank for locomotive supply is usually 20 ft. from top of rail to bottom of tank. With from 16 to 20 ft. of water in a tank, a 12-in. penstock with 1,000 ft. of 14-in. main will deliver from 3,500 to 4,000 gal. per minute, and for economic reasons, it would not be practical to exceed a height of 20 ft. to the bottom of the tank in ordinary practice.

FOUNDATIONS.

Rock is the best of all natural sub-foundations and is good for a safe bearing load of from 15 to 100 tons per square foot, varying from the soft deposit rocks to the hardest native bed rock. Some authorities claim that rock in its native bed will bear any load that can be brought upon it by any artificial structure.

Clay soils vary from shale to the softer wet clays and are excellent sub-foundations when dry and in thick beds. The shales and slate which may be classed as clay soils will support almost any load, while clay proper is good for a load of from 3,000 to 8,000 lb. per sq. ft., the safe load being dependent on the moisture present and on the clay being well confined. Clay has an added advantage in that it is easily excavated and seldom requires sheeting in shallow foundations. Soft clay with considerable moisture is a treacherous material for foundations and should not be depended upon unless reinforced with piling or in some other satisfactory manner.

Gravel or coarse sand when well cemented with clay, forms one of the best bearing soils and is good for a load of 2.000 to 8.000 lb. or more per sq. ft. The foundations of the New York pier of the Brooklyn Bridge and the Washington Monument both rest upon beds of sand and gravel.

Quicksand is a much abused term and may be applied to almost any sand. Strictly speaking, any fine sand is "quick" when saturated with water and subjected to a pressure that has a tendency to force it upward. Coarse sand resists this upward tendency more than fine sand; consequently quicksand is always very fine grained. Quicksand has no peculiar qualities and may be any one or more of the finer sands. Quicksand, mud and silt should never be relied upon for a foundation without driving piling, as such soils have practically no bearing power.

While the bearing loads of various soils as given above are conservative, in the construction of a foundation for a water tank it is a very good rule to limit the load on soil to 3,000 lb. per sq. ft. for all materials except rock. The excavation for the foundation should be below the frostline with a minimum depth of four feet. If there is any doubt as to the stability of the sub-foundation the footing should be spread or piling driven.

Specifications for a Concrete Foundation for Water Tanks.

1. The main body of the foundation shall consist of concrete mixed in the proportion of at least one part Portland cement to three parts sand and five parts broken stone or gravel.
2. The top 18 in. of each foundation pier shall consist of concrete mixed in the proportion of one part Portland cement to two parts sand and three parts broken stone or gravel and given a sidewalk finish.
3. The cement used shall be a standard brand of Portland cement fresh and not damaged by weather.
4. The sand used shall be clean, sharp and coarse, free from clay, loam and all foreign matter.
5. The broken stone or gravel shall be made up of firm and durable stone, no piece larger than two inches in greatest dimension. It shall be free from clay, loam and all foreign matter.
6. The volumes of cement, sand, broken stone or gravel shall be accurately measured.
7. The forms to bring the foundations to the desired shape shall be substantial and of timber of such thickness and stiffness and so braced that they will not yield when the concrete is placed. The forms for such parts of foundations as are above ground shall be built of surfaced lumber.
8. The cement, sand and stone or gravel shall be thoroughly mixed dry until of a uniform color. Enough water shall then be added to procure a uniform "wet mixture," the mixing continuing during the addition of water. After mixing, the concrete shall be deposited immediately in the foundation. Concrete shall not be used which has begun to set and no re-tempering shall be allowed. Concrete shall be compacted by spading or ramming.
9. Excavations shall be free from water before concrete is poured.
10. Concrete shall not be poured during freezing weather unless necessary. In such case the cement and crushed stone or gravel shall be heated before mixing and hot water used. After being poured, the concrete shall be protected in such a manner as will prevent freezing for three days.
11. If possible, each body of concrete shall be poured as a unit.
12. The tops of the foundation piers shall be at least 12 in. above the ground level. They shall be level and the tops of all in the same horizontal plane.

SUB-STRUCTURE.

There has been but little variation in the methods of constructing frames or towers for wood tanks, the common practice being to use a 12-post structure of 12-in. by 12-in. timber braced according to the height.

Steel frames for wood tanks and in a great many instances for flat-bottom steel tanks have also been of the 12-post type. The American Railway Engineering Association, found in 1910, in answer to inquiries sent out that of the roads reporting, 82 per cent of the 50,000 gal. tanks had 12 posts, 10 per cent 16 to 26 posts and 8 per cent 4 posts. Of the 75,000 gal. tanks reported 100 per cent had 12 posts with two exceptions, one with 21 posts and one with 16 posts. Of the 100,000 gal. tanks 100 per cent had 12-post frames with one exception of 4 posts. The general practice of constructing 12-post tank supports is explained in the fact that with a 12-post structure it is possible to secure a better distribution of the load than with a lesser number of posts, and to support every part of the tank bottom without an elaborate floor system. It also permits a good distribution of the foundation load. A plan of a typical 12-post steel tower is shown in the illustrations. Treated timber will prove more economical than untreated for the construction of towers for flat-bottom tanks, notwithstanding its higher first cost as treated timber will have a much longer life and does not require painting.

For the purpose of comparing the cost of treated and untreated timber and steel towers the following table is submitted. All towers are for 100,000 gal. tanks with bottoms 20 ft. above the top of rail:

Cost of a 20-ft. creosoted wood tower:

9240 ft. B. M. yellow pine, @ $25	$231
Treatment @ $12	111
Framing @ $4	37
Iron work and handling	116
Erecting	105
Total cost	$600

Cost of a 20-ft. untreated wood tower:

9240 ft. B. M. yellow pine @ $25	$231
Framing @ $4	37
Iron work and handling	112
Erecting	95
Painting	45
Total cost	$520

Cost of a 20-ft. steel tower:

Steel tower	$800
Erection	105
Painting	45
Total cost	$950

The comparative cost to build and maintain the above towers follows:

Creosoted wood tower (estimated life 25 years)

First cost	$600
Capitalized cost to renew	250
Capitalized cost insurance 1 per cent	120
	$970

Untreated wood tower (estimated life 10 years)

First cost	$520
Capitalized cost to renew	827
Capitalized cost to paint	209
Capitalized cost insurance 1 per cent	104
	$1,660

Steel tower (estimated life 40 years)

First cost	$950
Capitalized cost to renew	157
Capitalized cost to paint	209
	$1,316

From these figures it would appear that the treated timber tower was more economical than either the steel or the untreated wood tower. The capitalized cost to build and maintain the creosoted tower being $689 less than the untreated timber tower and $346 less than the steel tower. These figures will of course apply only to towers of standard height for locomotive supply. A steel tower will undoubtedly prove more economical and satisfactory for tanks on elevations greater than 20 ft.

Wood Tanks.

Most of the water tanks used for railway water service in the past have been constructed of wood, and while other materials are being used extensively for this purpose, there is no question but that timber will continue to enter into the construction of tanks of 100,000 gal. capacity, and under. Acknowledgment is given the U. S. Department of Agriculture and the Forest Service for much of the information on the various timbers suitable for water tanks.

Tank Timber.

The principal woods of the United States used in tank construction, given in the order of their production in 1913 are: Douglas fir, white pine, cypress, redwood and cedar. The total quantities of lumber sawed by kinds of wood for 1910, 1911, 1912 and 1913 is as follows. (Quantities given in thousand feet B. M.)

	1913	1912	1911	1910
Douglas fir	5,556,096	5,175,123	5,054,243	5,203,544
White pine	2,568,636	3,138,227	3,230,584	3,352,183
Cypress	1,097,247	997,227	981,527	935,659
Redwood	510,271	496,796	489,768	543,493
Cedar	358,444	329,000	374,925	415,039

Douglas Fir stands second in production of woods in the United States, and is the cheapest timber used in the construction of water tanks. It is found on the Pacific Coast from British Columbia to central California on the west slope of the Cascade, Sierra Nevada and Rocky mountains from British Columbia to Mexico. It is most abundant and in the largest sizes in Washington and Oregon. It is available in long lengths and is suitable for the construction of large tanks. It is fairly durable in tanks, select timber having a life of about 16 years. This is probably the most abundant timber available for tanks. Estimates by the West Coast Lumber Manufacturers' Association show that, at the present rate of cut, there is Douglas fir now standing sufficient to supply the market for 150 years without any reforestation.

The production of Douglas fir by states in 1912 is as follows:

	Feet	Per Cent.
Washington	3,381,395,000	65.3
Oregon	1,589,670,000	30.7
California	105,625,000	2.0
Idaho	51,845,000	1.0
Montana	39,325,000	.8
All other states	7,263,000	.2
	5,175,123,000	100.0

White Pine stood fourth in the production of woods in 1912, but at least four species are covered by the statistics. Common white pine is the most common and grows in New England, the Lake states, and in New York, Pennsylvania and southward along the Appalachian ranges of mountains. Norway pine is now cut chiefly in the Lake states, but its range extends eastward to New England, though it does not run very far south of the northern tier of states. Jack pine is a small tree, not of great value for lumber, and practically of no value as a tank material, but such as is cut passes for white pine, at least in the statistics. The western or Idaho white pine resembles the eastern or common white pine more than does the Norway or the Jack pine. Its range extends through Montana, Idaho and Washington, and to some extent into the bordering regions. Michigan, which for many years led all other states in the production of white pine lumber, ranked seventh in 1912. Minnesota led in 1912 with an output of white pine lumber more than three times as great as that of its nearest competitor. This state has doubtless passed the period of greatest production, and a decline may be expected soon. It is not likely that the decline will be as rapid or that the output will fall as low as that of Michigan, as Minnesota is practicing better forestry methods than obtained in Michigan.

The production of white pine lumber by states follows:

State	Feet B. M.	Per Cent Distribution.
Minnesota	1,225,674,000	39.1
Wisconsin	397,549,000	12.7
Idaho	309,564,000	9.9
Maine	280,145,000	8.9
New Hampshire	240,215,000	7.7
Massachusetts	143,119,000	4.6
Michigan	141,003,000	4.5
New York	76,355,000	2.4
Pennsylvania	71,870,000	2.3
North Carolina	60,727,000	1.9
Washington	41,762,000	1.3
Virginia	26,193,000	0.8
Tennessee	23,646,000	0.8
Iowa	22,324,000	0.7
West Virginia	19,740,000	0.6
Vermont	16,664,000	0.5
Connecticut	16,422,000	0.5
All other states	25,255,000	0.8

Cypress grows in the United States in seven different species. Bald cypress is the only one of great commercial importance. It is found in commercial quantities in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Maryland, Missouri, North Carolina, South Carolina, Texas and Virginia. The common cypress is a deep swamp tree and little is cut where the ground is not under water during a considerable part of the year. Some of the most extensive logging operations are carried on more on water than on land. The work is expensive because of the extra work required to get the logs to the mills. Many of the cypress forests consist of old timber. Young stands are not abundant, and cypress gives little promise of supplies after present sources have been exhausted. It is a tree of very slow growth, and mature timber is from 100 to 400 years old. Cypress is not being planted and perhaps never will be. Natural reproduction must be depended upon and this does not by any means keep pace with the cutting. Depletion of the supply in the immediate future is not likely, but every year sees a smaller quantity to draw from.

The largest returns for cypress lumber are from Louisiana, but six other states are credited with more than 20,000,000 ft. each. Cypress mills are usually large, the average production of this lumber per mill in 1912 exceeding 1,000,000 ft., while in Louisiana the average was 5,785,000 ft. The total production of cypress lumber was a little larger in 1912 than in the preceding year, but three states—Louisiana, Arkansas and Mississippi—show decreases.

State	Feet B. M.	Per Cent Distribution
Louisiana	653,727,000	65.6
Florida	101,429,000	10.2
Georgia	62,941,000	6.3

Arkansas	43,238,000	4.3
North Carolina	30,068,000	3.0
South Carolina	26,338,000	2.6
Missouri	24,146,000	2.4
Mississippi	17,626,000	1.8
Virginia	12,038,000	1.2
All other states	25,676,000	2.6

Redwood requires no table to give the production, because practically the whole quantity is produced in California. Two species occur there, the red wood proper (Sequoia sempervirena), from which most of the redwood lumber of commerce is obtained, and the "big tree" (Sequoia washingtoniana), which is confined to few groves on the western face of the Sierra Nevada mountains. The common redwood grows in the fog belt near the coast, from central California to Oregon. The trees are of great size, many exceeding 10 ft. in diameter and 200 ft. in height. The "big tree" redwoods are the largest trees in the world, though not the tallest. A few of the largest trunks have produced more than 100,000 ft. of lumber. The exports of this wood are relatively large, though after supplying the demands for export and the markets on the Pacific coast, there is a surplus which reaches all of the largest markets in the central Mississippi valley and in the eastern states. The production of redwood lumber, which varies but little from year to year, was 496,796,000 ft. in 1912, and was sawed by 42 mills.

Cedar for the construction of large tanks is probably available (in any quantity) only in Washington, Idaho and Oregon, these three states producing over 63 per cent of the total, most of which is known as Washington red or eastern cedar. The production of cedar lumber in the United States in 1912 was somewhat below that of the three preceding years, while 1913 showed a slight increase over 1912. There will probably be a falling off in production in the east, but the western forests contain enough lumber to supply an increased demand for a long term of years. The production by states in 1912 follows:

State	Feet B. M.	Per Cent Distribution.
Washington	153,518,000	46.7
Idaho	35,165,000	10.6
Tennessee	31,296,000	9.5
Oregon	20,654,000	6.3
California	18,507,000	5.6
Virginia	18,283,000	5.6
Michigan	15,390,000	4.7
Alabama	5,235,000	1.6
Maine	4,682,000	1.4
Missouri	4,285,000	1.3
North Carolina	3,970,000	1.2
Wisconsin	3,887,000	1.2
All other states	14,128,000	4.3

The following table gives the average value per thousand feet F. O. B. mills by kinds of wood from 1906 to 1912 inclusive:

	1912	1911	1910	1909	1908	1907	1906
Douglas Fir	$11.58	$11.05	$13.09	$12.44	$11.97	$14.12	$14.20
White Pine	19.13	18.54	18.93	19.16	18.17	19.41	18.32
Cypress	20.09	20.54	20.51	20.46	21.30	22.12	21.94
Redwood	14.13	13.99	15.52	14.80	15.66	17.70	16.64
Cedar	14.45	13.86	15.53	19.95	19.03	19.14	18.12

While the prices given above do not represent the value of tank stock they indicate the range of prices of the various timbers during the seven-year period.

The following figures are based on clear tank stock in suitable sizes and lengths for the construction of large tanks.

	White Pine.	Cypress.	Douglas Fir.	Redwood.	Cedar.
3 in. x 12 in. x 30 ft.	None	$88	$40	$60	None
3 in. x 6 in. x 20 ft.	$60	64	34	45	$65
3 in. x 6 in. x 18 ft.	55	60	32	45	65
3 in. x 6 in. x 16 ft.	50	54	30	45	65

The prices of course fluctuate with the market but the above figures are fairly representative of the prevailing prices F. O. B. cars at the mills.

Life of Timber.

The life of timber in a water tank will vary widely with climatic conditions and with other factors which cause or prevent decay. The mechanical strain or wear a tank may be subjected to will also affect the life of the timber. Many tanks have been replaced, not so much because of the deterioration of the tank itself as of the decay of the structure supporting the tank, or more probably the decay of the floor and chime joists immediately supporting the tank bottom. All these factors have to be given consideration so far as the length of life, and the general utility of various timbers and other material used in wood tanks are concerned.

The life of a wood water tank, no matter of what kind, depends largely upon the care in selecting and inspecting the timber entering into the construction. It is needless to say that the best selection and best quality of a cheaper timber will give a better and more lasting tank than a poor selection of high priced timber. For example, a white pine or Douglas fir tank of selected material free from any defects that would impair its durability is undoubtedly a better and cheaper tank than a cypress tank which, while it might fulfill the purchasing agent's inquiry for a cypress tank, would be full of defects and imperfections, offering a ready opportunity for early decay. Few railroads properly specify a tank in their inquiries. They may give elaborate specifications for the hoopage, as well as for the dimensions of the tank itself, and may specify the kind of timber that shall be used, but they do not rigidly specify and inspect the quality and grade of timber to be furnished. Fig. 2 is a good illustration of early decay due to poor inspection of tank timber. The tank was taken down in 1914 after being in service 7 years, and 17 of the staves were found in a similar condition to those shown in the photograph. These staves were replaced with clear staves and the tank reconstructed at another point. This is now a better tank after 7 years' service than when first built as the defective timber has been replaced with first class material. Fig. 3 shows white pine staves taken from a 16-ft. by 24-ft. tank after 23 years' service and show but little decay. Fig. 4 shows bottom planks taken from a cypress tank after 15 years of service, and as may be seen, aside from wear, they are as sound as the day the tank was built. This tank was rebuilt in 1914 on account of a change in the location of the water station and, with the exception of six or seven staves, was perfectly sound.

The average life of the various timbers entering into the construction of water tanks is about as follows:

Cypress	40 years
Redwood	30 "
Cedar	30 "
White pine	20 "
Douglas fir	16 "

There are doubtless many who will dispute the above figures as applying to their particular localities and conditions, but from the information available this may be taken as a good average of the life of tank timbers. It must be borne in mind that to secure this life the most rigid specifications and inspection must be adhered to. Cypress is beyond question the best timber for the construction of water tanks. Next is the Pacific Coast redwood, which is an admirable tank material, but is little used in the central and eastern states. Eastern cedar, which is practically the only one of the cedars available for tanks, makes an excellent tank when the best grade is obtained. White pine is also a very good tank material, but is rarely available in suitable sizes and lengths for large tanks. Douglas fir is obtainable in almost any size and length, but is of comparatively short life.

Specifications for a Standard 100,000 Gal. Tank.

A 20-ft. by 30-ft. water tank, consisting of staves and bottom planks, shall be made of tank stock heart red cypress, sound, seasoned, out of wind, free from shakes, sap, pitch pockets or streaks, unsound knots, loose knots, knots in clusters, and large knots extending through the material. Small loose or unsound knots may be bored out and the holes thoroughly plugged with the same material as the tank. Material having knots in the edges will not be accepted.

Staves shall be 6 to 8 in. wide and 20 ft. long, of uniform width end to end, and 3 in. thick, with the edges accurately planed on radial lines from the center of the tub. The croze in each stave shall be 3 in. in the clear from the end of the stave with a ⅝-in. gain and shall be accurately cut to uniform dimensions on one circle for all staves. Three one-inch dowel pins made of the same material as the staves shall be furnished with each stave, and the staves shall be bored for dowel pins properly spaced. The bottom planks shall be 12 in. wide and 3 in. thick. The bottom shall be 30 ft. in diameter with 3½-in. chamfer. All pieces shall be full length without splicing, and every joint machine-made and perfect. The planks shall be joined by one-inch dowel pins on 30-in. centers, of the same material as the bottom. This specification may be changed slightly when different timbers are designated.

While the material in the tub is perhaps of the first importance, it does not embrace the entire structure. The frame, frost box and roof, are constructed of entirely different timber than the tank proper. The most important feature, and the one that requires the most attention is that of hoops. In this age of steel it is a difficult matter to get genuine wrought iron hoops, and the quality of the hoops purchased in the open market as wrought iron is uncertain.

When these various features of tank construction are given consideration, it would not be fair to base the life of wood tanks altogether on the life of cypress or other timbers entering into the construction of the tub. Where the structure consists of a wood tank mounted on a steel or treated timber frame, the question of the life of the structure as a whole is further complicated. The life of the treated frame will depend on the treatment applied to the timber and may represent a longer or shorter life than the tank. As a means of fixing the approximate life of wood tanks on different types of frames the following tables are submitted:

Table showing the life of various timbers suitable for the construction of tank frames:

Long leaf pine	Untreated	10 years
Long leaf pine	Treated creosote	25 years
Long leaf pine	Treated zinc-chloride	15 years
Loblolly pine	Untreated	3 years
Loblolly pine	Treated creosote	25 years
Loblolly pine	Treated zinc-chloride	15 years
White oak	Untreated	15 years

Table showing life of hoops:

Flat hoops	Steel	3 to 5 years
Flat hoops	Iron	15 years
Oval hoops	Steel	6 years
Round hoops	Steel	10 years

Manufacture of Tanks.

When properly manufactured, a machine-made wood tank is better than one framed by hand. Of course if the proper care is not taken with the machine, or if the machines are not properly set for each tank it is very likely that the framing or jointing will be poorly done.

The stave jointing, as well as the other operations in a machine-made tank, are done by special machinery. In jointing the staves, they are held in place by clamps on long traveling tables in the same position they will have when in place in the finished tank. This insures uniform bearing of the stave joints throughout both the length and thickness of the staves. The outside of the stave is surfaced convex and should have a true radius of the diameter of the tank so that the hoops will have a bearing throughout the width of each stave, regardless of what its width may be. Thus, the hoop should be in contact with a 10-in. stave for the full width the same as with a stave only 4 in. wide. The crozing of the staves to receive the bottom is also done by special machinery. The stave is hung in a swinging frame which travels in an arc corresponding with the diameter of the tank so that when the croze is cut it is circular in shape and will be completely filled by the circle of the tank bottom when the stave is well driven up.

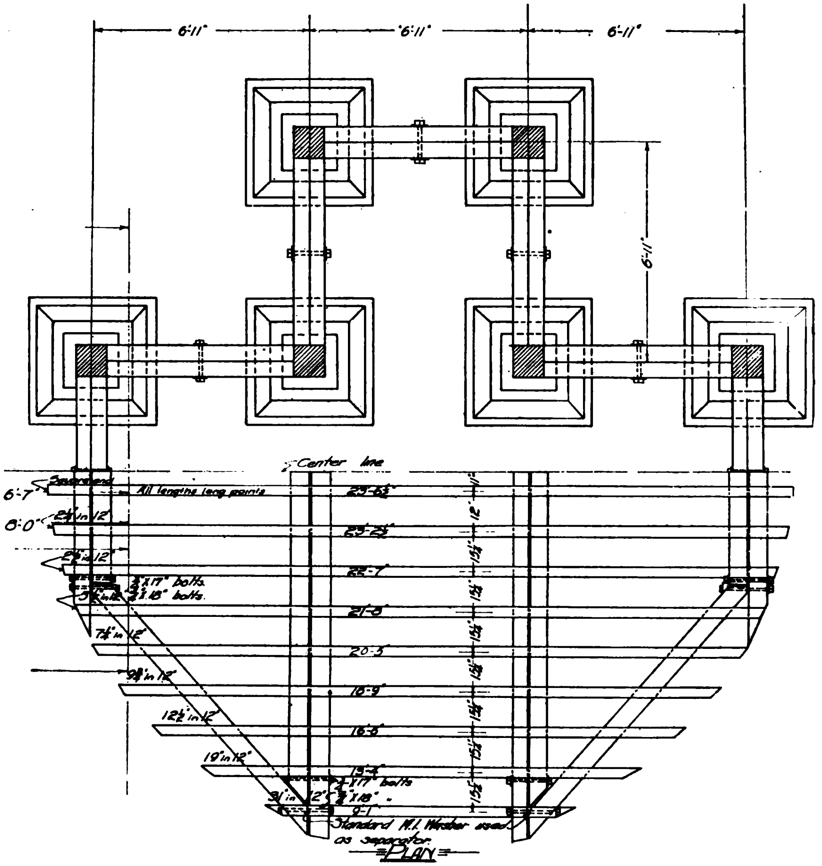
The tank bottom should be carefully laid out, doweled and put together by hand. It is then scribed and cut to circle on a band saw, dressed and chamfered and the planks marked and numbered consecutively. The staves are then put on the tank and driven up, making the complete tank ready for the hoops. This enables the inspector to examine the tank carefully from the inside as well as the outside for possible defects in the lumber that may have escaped the timber inspector and the machine operators. There are virtually four inspections of the timber before it is shipped and the possibility of inadvertently overlooking a defective stave or bottom plank is remote.

While the tank is set up each stave should be marked consecutively, its position on the tank bottom also marked and a number corresponding with the number of the stave placed in the proper place on the tank bottom. This not only insures a perfect fit of the tank throughout, but simplifies and lessens the work of erection in the field.

Hoops.

The hoops comprise the most important feature in the maintenance of water tanks. With very few exceptions tank failures may be traced directly to the failure of the hoops.

Flat Hoops have been used almost universally up to the last few years, and as practically all of the older tanks are equipped with them, it is a popular belief that the flat hoop is more subject to failure than any other shape. This is probably true if the hoops are not constructed of the proper material and given the proper attention. So far as corrosion is concerned the flat hoop has a greater surface exposed than a hoop of different section; 40 per cent of this surface is next to the staves. Aside from presenting a greater surface to the corrosive elements this leaves 40 per cent of the hoop inaccessible to inspection. This makes a strong argument against the flat hoop on the score of corrosion. On the other hand it is easier to apply, forms a more uniform bearing against the stave, does not crush the fibre of the wood, conforms more readily to the circle of the tank, can be secured more readily for repairs than the odd shapes (with the exception of round hoops), will not break as easily as a hoop of different section, and lends in part at least to the life of the stave the loss due to corrosion.



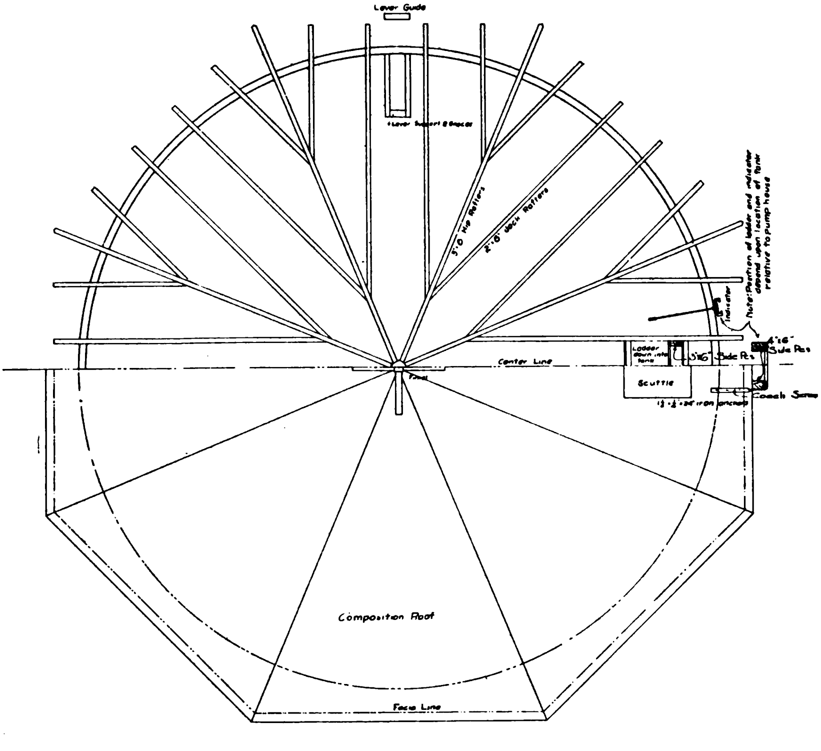
Foundation Plan and Floor System for 16 ft. x 24 ft. Tank on Wood Tower.

Round Hoops have come into general use only within the past few years, chiefly through the efforts of the insurance people. Round hoops are required on tanks used for sprinkler and other fire protection systems. The round hoop lends itself readily to inspection; any corrosion or deterioration may be easily seen and the whole surface of the hoop is painted more readily. One great objection to this type of hoop is the little bearing it has on the stave which has a tendency to cut into the wood, crushing the fiber and inducing decay. This decay is further aggravated by the accumulation of dirt, cinders and moisture in the pocket formed by the upper half of the hoop.

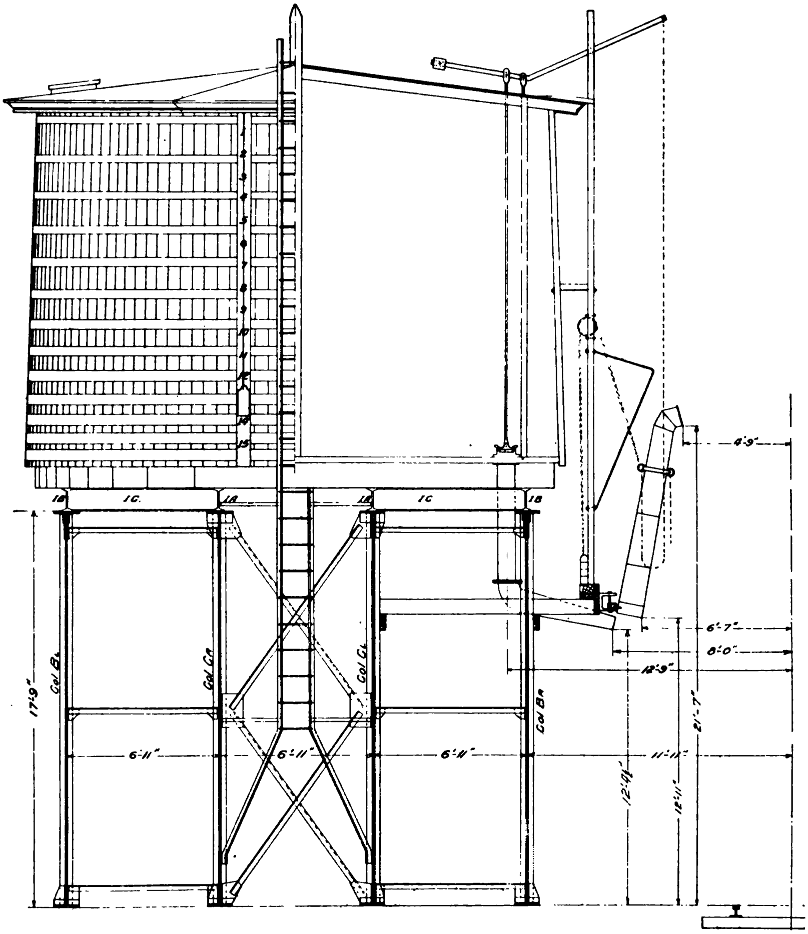
Oval Hoops or half round hoops have not come into general practice while at the same time they have much to commend their use. They have the advantages both of the flat and half round hoop in that they give an even flat bearing to the stave and are heavier at the center like the round hoops, and they are not so quickly weakened by corrosion. The principal objection that could be offered to this type of hoop is that it is much harder to apply than either the flat or the round hoop on account of the difficulty in making it conform to the circle of the tank. The rigidity of this hoop is also objectionable in the fact that when the staves are softened by partial decay there is a tendency for the hoops to straighten out and throw the tank out of round, especially if the tank is empty or only partly filled with water. The strain and mechanical wear on a tank from the movement caused by the hoops forcing the staves inward as the tank is emptied and the water forcing the staves out as it is filled are very great and will contribute to early decay.

On page 126 of the 1910 Proceedings is shown standard lugs as used on various railroads. These lugs are fairly representative of those in general use. Various methods are used to fasten them to the hoop, but it would appear that riveting is the most popular and economical method of applying lugs to the flat hoops. The method of applying lugs to other types of hoops will depend largely on the shape of the hoops. The single bolt is generally accepted as preferable to the double bolt for the reason that it is easier to apply it and there is a uniform pull on the lug and hoop. With the double bolts there is a danger of breaking the lug or shearing off the rivets unless great care is used to keep the bolts pulled up uniform in tightening the hoops.

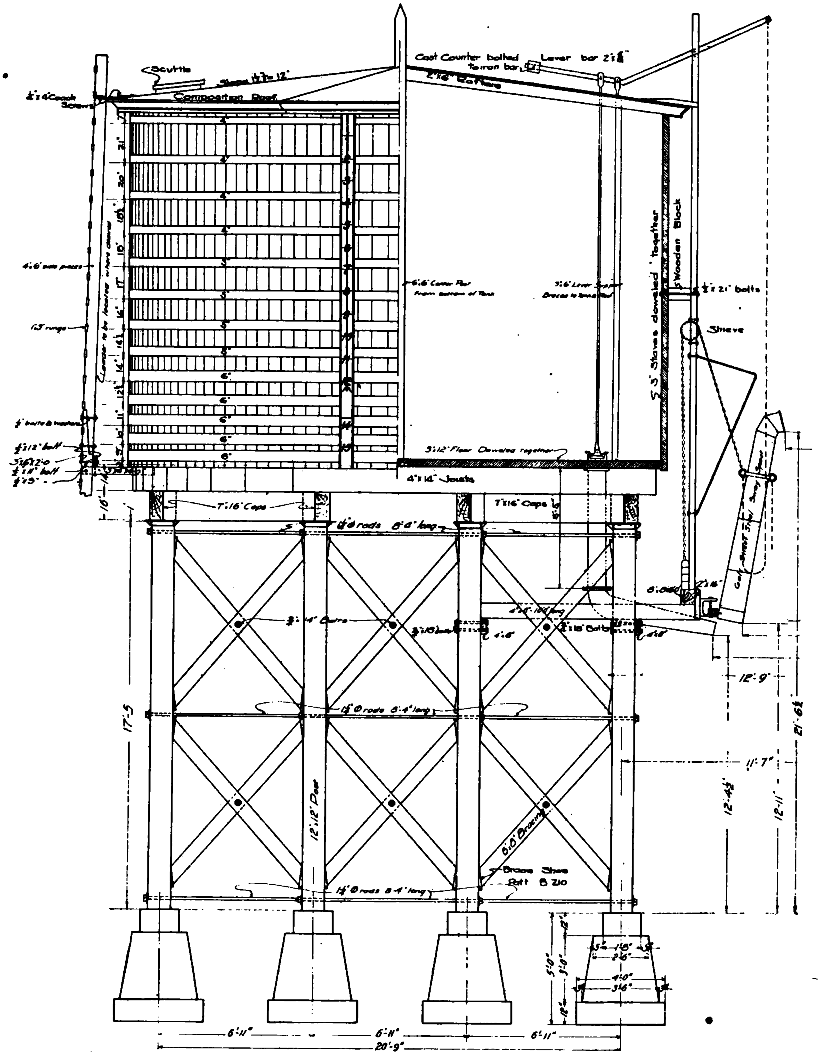
Several factors enter into the life of a tank hoop, the most important being the material of which the hoop is constructed. The hoop should be constructed of wrought iron, but as but few railroads pay much attention to this feature the hoops usually furnished are largely of steel. In fact there is a question as to whether wrought iron may be purchased in the open market in suitable sizes for tank hoops. The question of the quality of iron is of far more importance than the shape of the hoop. The seeming indifference of the many railroads to this feature compels



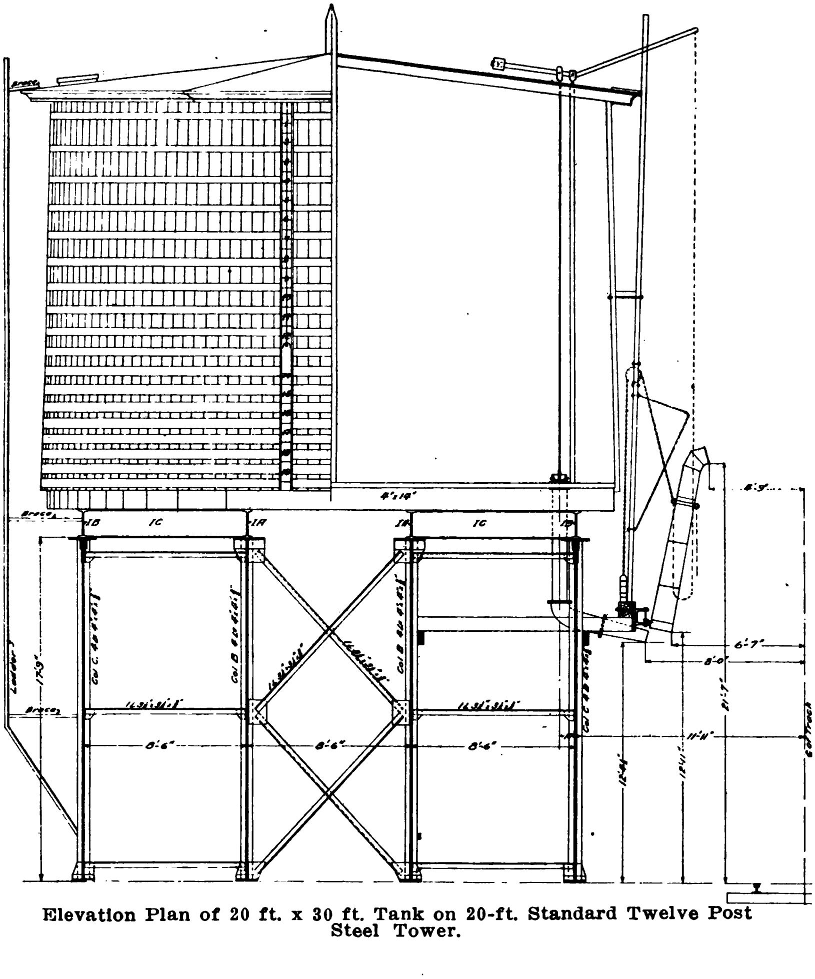
Plan of Roof and Rafters for 16 ft. x 24 ft. Tank.



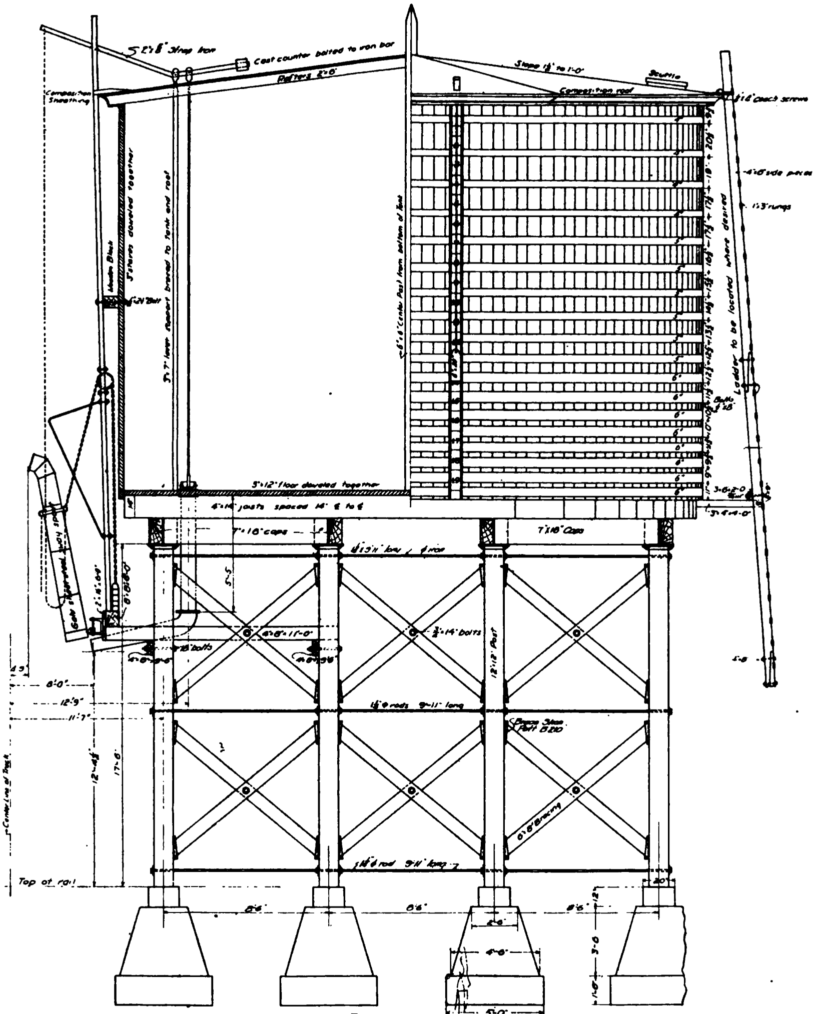
Elevation Plan of 16 ft. x 24 ft. Tank on 20-ft. Standard Twelve Post Steel Tower.



Elevation Plan of 16 ft. x 24 ft. Tank on 20-ft. Standard Twelve Post Wood Tower.



Elevation Plan of 20 ft. x 30 ft. Tank on 20-ft. Standard Twelve Post Steel Tower.



Elevation Plan of 20 ft. x 30 ft. Tank on 20-ft. Standard Twelve Post Wood Tower.

the few who insist on wrought iron to pay a premium on the cost of hoops that even at the best do not come up to the standard that should be maintained. The discussion of tank hoops in the Proceedings of 1910 indicated that there were any number of tanks in service with flat iron hoops that had been in use from 16 to 35 years and from the general opinion expressed by the members the flat wrought iron hoop was the most satisfactory from every standpoint. No evidence has been found in the preparation of this report that would change this conclusion.

Illinois Central Specifications for Standard Flat Tank Hoops for a 20-ft. By 30-ft. Tank.

24 wrought iron hoops 6 in. wide, ¼ in. thick and 32 ft. long.
18 wrought iron hoops 5 in. wide, ¼ in. thick and 32 ft. long.
12 wrought iron hoops 4 in. wide, ¼ in. thick and 32 ft. long.
48 lug castings, pattern No. B-207-IC Std.
36 lug castings, pattern No. B-208-IC Std.
24 lug castings, pattern No. B-209-IC Std.
24 bolts 1-¼ in. x 26 in. with 6 in. threads on each end and 2 hex. nuts.
18 bolts 1⅛ in. x 26 in. with 6 in. threads on each end and 2 hex. nuts.
12 bolts ⅞ in. x 22 in. with 6 in. threads on each end and 2 hex. nuts.

Cast lugs are to be riveted on the hoops with the exception that lug shall be left off one end of every third hoop of the same size, the lug to be shipped loose. Hoops and lugs shall be given a shop coat of red lead.

An analysis shall show the following chemical requirements:

Total carbon not to exceed	0.06
Manganese not to exceed	0.25

The finish shall be true to size and free from seams, slivers and other defects. They must have an elongation of 22 per cent in 8 in. The elastic limit shall be not less than one-half the tensile strength. They must bend hot or cold, 180 deg. flat with no fracture and must show a fibrous structure.

Roofs.

Eliminating the question of adding to the appearance of the structure, the utility of a roof on a water tank is divided between frost prevention and protection from dirt. In the northern states there is no question as to the necessity of the roof on account of protection from frost. In the southern states the conditions are entirely different and there are a great many who insist that a roof on a water tank is an unnecessary luxury and can be dispensed with readily.

Taking up the question of roofs in cold climates, as a matter of frost prevention, there is no doubt but that water tanks should be well roofed. Decks constructed with double layers of dressed and matched boards with building paper between is of great value as a protection from frost. The objection to this type of roof and decks so constructed with the joists beneath them is that they are subject to rapid decay, on account of moisture and poor ventilation. Some roads are constructing the deck of two layers of 2-in. by 8-in. timbers spaced ¼ in. apart. It is claimed that this is as nearly frost proof as the double decking and it certainly is more substantial as far as decay is concerned.

The roof should be conical of 1-½ in. to 1 ft. pitch, with 14-in. eaves. The roofing material should be a good composition roofing, or good felt, with tar and gravel.

Considering the roof as a protection to the water, the causes contributing to dirt in the water tanks will be given in the order of their importance. The common English sparrows and pigeons are the worst offenders. The sparrow is always present either in town, or country, while the pigeon is usually present only in towns. The sparrows build their nests by dozens under the eaves, and in the frame work of the tank, and contribute largely to the pollution of the water. Especially is this true when they are rearing their young, as the young birds in attempting to fly often meet an untimely end in the tank. While pigeons do not usually build in tanks, they frequent them and contribute to the fouling of the water. Thus, unless the tank and roof are made bird proof, the roof is rather a hindrance than otherwise.

Soot and cinders affect the water in an open tank to a certain extent, especially in a terminal or a manufacturing community, and if the water is used for drinking purposes, a tank should be roofed. Dust and leaves may be blown about and deposited in the tank, but not in sufficient quantities to materially affect the water. Thus it may be assumed that where the tank is not affected by frost, or the water is not used for drinking purposes, the only advantage in a roof is to add to the sightliness of the structure.

Protection from Frost.

There are several points of primary consideration in the protection of water tanks and tank fixtures from frost. The protection required will be determined by climatic conditions and should be designed to afford protection against the most severe weather conditions likely to prevail. This condition can not be based altogether on the minimum temperature, but upon the duration of low temperatures as well. For example, a temperature of 20 deg. below zero maintained for two weeks offers far more serious problems for frost proofing than a temperature of 40 deg. below for only two days.

The source of water supply is another important feature. Where water is pumped from streams or ponds, the temperature is lower than where pumped from wells. As a result more insulation is required where surface water is used than with an underground supply. Where the pumping is continuous, or nearly so, and there is practically a constant flow of water to the tank, less protection is required than where the pumping is intermittent.

Where it is difficult to protect the supply line from frost properly the pipe should be extended to the top of the tank and the line drained when not in use. The best type of frost box for supply pipes to wood tanks is one constructed of dressed and matched lumber, and lined with building paper with alternate 2-in. air spaces, the number of air spaces required varying with weather conditions. Five air spaces should be effective against a minimum temperature of 30 deg. below zero. It is important that the frost box extend into the ground well below the frost line to get the benefit of the radiation from the earth. That part of the box below the ground should be concrete or brick. It is unnecessary to carry the air spaces below the ground, but the joint at the top of the foundation should be absolutely tight. The lumber used in the construction of a frost box should be thoroughly seasoned to prevent shrinkage, and the box should be made as nearly air tight as possible.

Some northern roads completely house in their smaller tanks, and heat them with stoves or steam. The usual type of construction is octagon in shape, ceiled and lined with building paper between the walls. This leaves a dead air space between the inner and outer walls. The wall is carried about two feet above the top of the tank and the entire structure is housed in. The method is applicable only to the smaller tanks, is very expensive and is a bad fire risk. Where pumps are operated by steam it is sometimes practical to run the exhaust pipe through the frost box and tank. This is a safe and effective method of protection from frost, but is practical only where the tanks are in close proximity to the pumping stations.

In extremely cold climates, the usual method is to house in the substructure of the tank and install stoves, extending the stove pipes up through the tank, the portion through the tank being standard wrought iron pipe. This method is effective, but offers a hazardous fire risk, as well as requiring a great deal of attention to keep up the fires.

It is often difficult, if not impossible, to keep the outlet pipe and valve from freezing without a stove or heater of some kind, but they should not be used if there is any other practical method to follow, as by using stoves under wood tanks the fire risk is increased ten-fold. The outlet valve should be kept in good condition, as leakage will cause ice to form in the outlet pipe. Locomotives on many roads are equipped with small sections of steam hose for thawing out outlet pipes and valves. Another effective method is to bring the end of the spout down over the stack of the locomotive and turn on the blower. This throws a hot blast against the outlet pipe and will thaw out a heavy accumulation of ice in a very short time. This should be used only as a last resort, as it plays havoc with the spout on account of the intense heat.

The winters vary in severity to such an extent in different parts of the country and the tanks constructed present such varied types that it is difficult to present methods of frost proofing applicable to all cases. However, the conclusion may be drawn that, with the modern type of wood tank construction delivering water to locomotives through penstocks, the riser pipes may be effectually protected by properly constructed frost boxes provided the consumption of water per 24 hrs. is equal to the capacity of the tank. In the extreme north, where the winters are most severe and where the water consumption is small, a frost box would hardly prove adequate as the water in the tank itself may freeze solid. Under these conditions a heater of some kind must be provided to keep the ice from forming. In some cases the riser pipes of steel tanks are surrounded by wood frost boxes with air spaces as protection from frost. This is not good practice as it hastens the corrosion of the steel and does not permit proper inspection and painting. The best method of protecting a conical bottom steel tank from frost is by installing a stove or other heater in the riser pipe. This is shown in the illustrations, herewith. The flat bottom steel tank may be protected in the same manner as the wood tank.

STEEL TANKS.

Tanks made of iron plates, and later on of steel plates, first made their appearance in the last half of the nineteenth century. The earlier types of iron tanks on towers were flat bottom tanks and were so built with the exception of a few conical or " V " shaped bottoms, up to about 25 years ago, when the first steel tanks with hemispherical bottoms were constructed. Tanks built in this form did away with the expense of the beam and girder construction necessary to support flat bottom tanks. This also simplified the distribution of the loads and reduced the cost of construction. This new type of tank construction first appeared in municipal work; later on it was used extensively in the industrial field for storage and fire protection. The last to advance from wood to steel tanks were the railroads and they are but now in the transitory stage, although there are of course instances where iron tanks have been used for railway water service for half a century as with the Chicago, Rock Island & Pacific old iron tank shown in an accompanying cut.

Railroad requirements are peculiar to themselves. Accordingly it has been necessary to evolve certain forms to satisfy these requirements. It is quite essential that tanks for locomotive supply be within narrow ranges of elevation, and also that the tops of the tanks be at low elevations. While almost every type of tank has been used for railway service at some time, the modern conical bottom steel tank seems to meet the requirements to a greater extent than any other type. While the hemispherical bottom tank was a decided improvement over the flat bottom it does not entirely fulfill the requirements of a roadside tank for locomotive supply, the conical bottom being more satisfactory for the purpose of precipitating much of the matter carried in suspension by water from a surface supply. This feature more than all else has been instrumental in bringing the railroads to adopt the steel tank and has made the conical bottom tank standard on many roads. Another factor that has done much to bring the steel tank into favor is the growing scarcity of select material for the construction of wood tanks and the necessity for tanks of large capacity. It is hardly practicable to build a wood tank larger than 20 ft. x 30 ft., with a capacity of 100,000 gal. The result is that where the required capacity is in excess of this amount it is necessary to build more than one unit, which means a heavy maintenance expense, or to construct a steel tank. Unfortunately but little information can be obtained regarding the life of iron and steel tanks in railway water service. Such information as may be obtained consists chiefly of the records of tanks constructed of wrought iron erected before the introduction of steel tanks. Steel tanks have not been in use long enough to determine their exact period of usefulness. Previous to about 1880 wrought iron was used almost entirely in the construction of metallic tanks and while many tanks erected previous to this time are still in service, this can not be taken as an example of what may be expected of the modern steel tank, for while experts may differ as to the exact causes of corrosion there is no doubt that steel is more susceptible to corrosion than iron.

STANDPIPES.

Standpipes were among the earliest types of water tanks constructed in this country and were originally designed as a type of relief valves to eliminate the water hammer in pumps. When used for this purpose storage was not considered, the principal factor being height, this height of course being determined by the pressure required on the pumps.

A standpipe was erected at Winona, Minnesota, in 1876 which was 4 ft. in diameter and 210 ft. in height, with a capacity of 20,000 gal. Later on the diameter of the standpipes was increased and they were used for the storage of water, thereby avoiding the necessity for constant pumping. An example of the latter type is one erected at Greenville, Conn., in 1889, 80 ft. in diameter and 35 ft. high, with a capacity of 1,320,000 gal. While the standpipe would appear at first glance to be particularly adapted to the low heads required for delivering water to locomotives, it cannot be found to have ever been used to any great extent for this purpose.

The cost of maintenance of a standpipe is greater than of a well-designed tank and more foundation is required on account of the greater weight of water carried. The sizes of standpipes suitable for locomotive supply with capacity as given at about 20 ft. elevation is approximately as follows:

Total height of standpipes exclusive of roof, 46 ft.

50,000	gal.	capacity	18	ft. in	diameter.
75,000	"	"	22	" "	"
100,000	"	"	26	" "	"
150,000	"	"	31	" "	"
200,000	"	"	36	" "	"

The cost of these standpipes including roof, ladder, manhole and flanged openings for inlet and outlet pipes erected at any point in the United States east of a line running north and south between the Kansas-Colorado boundary is approximately as follows:

50,000 gal. tank of 5-16 in. and ¼ in. sheets	$1,850
75.000 gal. tank of 5-16 in. and ¼ in. sheets	2,270
100,000 gal. tank of ⅜ in., 5-16 in. and ¼ in. sheets	2,860
150,000 gal. tank of 7-16 in., ⅜ in., 5-16 in. and ¼ in. sheets	3,850
200,000 gal. tank of ½ in., 7-16 in., ⅜ in., 5-16 in. and ¼ in. sheets	4,950

The above prices cover the standpipe erected above the foundation. Fifteen to 20 per cent should be added to the figures to cover the transportation of men and material.

Iron and Steel.

The terms iron and steel as generally used mean but little when applied to a tank or other structure unless accompanied by specifications giving the analysis and physical characteristics of the material entering into its construction. The reason for classing a tank as iron or steel is often based wholly on the date of construction, the assumption being, and not without reason, that the building of iron tanks ceased with the advent of steel. It is also quite common to find the advocates of iron or steel, whichever the case may be, citing obscure cases of tank failures due to the use of one or the other. As examples of this we find where a wrought iron standpipe erected at Waterloo, N. Y., in 1886 collapsed in 1908, the failure being due to corrosion of the plates. Again we find a steel standpipe erected at Avalon, N. J., in 1897 was corroded through, and out of service in 1911. While these statements are undoubtedly true, neither case can be considered a fair average life of either an iron or steel tank.

Iron and steel are not two entirely different metals as many are inclined to consider them, but are both composed chiefly of the same element, iron, of which they contain from 93 per cent to 98 per cent, the difference between iron and steel being due to the remaining elements and methods of manufacture. There is no question but that each material has merits that the other does not possess at all, or at least only to a lesser degree. Undoubtedly wrought iron is a more durable material in a water tank than steel, on account of its greater resistance to corrosion; at the same time it is not proper to condemn a steel tank and attempt to fix its useful life by an occasional failure of this type of tank, probably due to a large extent to improper design and the rise of cheap and inferior grades of steel. Steel has replaced wrought iron to such an extent that competition among the manufacturers of wrought iron suitable for the construction of tanks has been practically eliminated. This raises the question as to the possibility of getting the same wrought iron it was possible to get a half century ago.

A comparative statement of the cost to build and perpetuate a steel and a wrought iron tank will show that a wrought iron tank will be more economical than a steel tank providing a life of 60 years or more can be obtained from the wrought iron tank, the estimated life of the steel tank being 40 years. The uncertainty of the material and possible future developments appear to justify the continued construction of steel tanks rather than a return to the wrought iron tank. As to future developments probably some form of alloy steel that will not corrode or will corrode very slowly will be obtainable. Such steel would permit of building tanks of thinner plates and should thus reduce the cost. Such alloys are not unknown at present but they are not available commercially.

Conical Bottom Tanks.

The type of steel tank which seems to meet the requirements of a railway more fully than any other is the conical bottom tank. (See illustration.) Properly speaking the bottom is more in the form of an ellipsoid and cone. The riser pipe or water leg may be made of ample size to prevent much of the trouble from freezing. The chief advantage of this type of tank is in the precipitation of mud and sediment for much of the matter carried in suspension is precipitated and collected in the bottom of the riser pipe where it may be washed out of the tank without interruption to service. It would be very hard to estimate the amount of mud removed from the water in this manner but with water carrying much suspended matter it is very great. Assuming that the water carries 50 grains per gallon of solids in suspension and that 40 per cent is removed by precipitation, it means that 7,000 lbs. of matter per million gallons of water is taken out of the water in the tank that would otherwise have to be washed from the boilers in the roundhouse as mud, or removed from the flues and sheets as scale. When the comparative costs of removal are considered the advantage of the settling drum is apparent.

PAINTING.

Very little can be said in regard to painting wood tanks and wood towers that is not applicable to almost any timber structure with the possible exception of the tub proper and from such information available the general practice of painting wood tanks does not seem to differ from that followed in painting any other timber structure. The important feature in painting a wood tank is to clean it thoroughly before applying the paint. This is especially true of the hoops. The side of the hoops next to the staves should be painted carefully when the tank is erected for it must be borne in mind that no paint will ever reach the under side of the hoop until it comes down from the tank. It is apparent that the outside and the edges of the hoops must receive careful attention to prevent the moisture penetrating the spaces between the hoops and the staves as much as possible. With the old style wood tank with a batter this was a difficult thing to do on account of the opening at the top of the hoop, but as the tanks now being constructed have no batter there is but little space between the hoops and the staves with a well-fitting hoop and the space may be closed effectually with paint properly applied. Paint should not be applied over rust or scale, but the hoops should be gone over carefully with wire brushes or scrapers. The secret of the life of paint on wood tanks is largely in preventing the water coming through the staves on account of allowing the tank to dry out at the top, where the water is muddy. It not only destroys the effect of the paint but presents a very unsightly appearance through the discoloration from the mud. The appearance of newly painted tanks is sometimes destroyed for this reason.

The 1912 proceedings contain a very complete discussion of the painting of structural iron and steel which is applicable in a general way to iron and steel tanks. It is comparatively easy to take care of the outside of the structure. The inside of the tank is not so easy but is quite as important. The theory has been advanced that the corrosion on the inside of a water tank which is covered with water and protected from the rays of the sun is practically negligible as compared with that on the part of the tank exposed to a wet-and-dry condition. In support of this theory the condition of two tanks after having been in service 16 to 18 years without painting on the inside may be cited. Both are steel tanks, the first a 100,000 gal. tank 101 ft. to the bottom, erected at Rensselaer, Indiana, in 1897. Up to January, 1915, the water had never been out of the tank and it had never been painted on the inside. The deterioration was reported as scarcely noticeable and the tank was practically as good as when first constructed. Another tank erected at McComb, Miss., in 1897 and 1898 of the same size and capacity of the Rensselaer tank was not painted on the inside with the exception of at the time of erection until 1913. The lower rings and bottom sheets were found in good condition, and showed no signs of pitting but the top ring of the tank which was subject to a variation of water levels was pitted and corroded. The analysis of the McComb water is as follows:

Ions		Hypothetical Combinations		
	Parts Per Million		Parts Per Million	Grains Per Gal.
Potassium,	4.0	Potassium nitrate	10.3	.60
Sodium,	16.0	Sodium nitrate	8.4	.49
Ammonium,	.1	Sodium chloride	37.1	2.16
Magnesium,	14.8	Ammonium chloride	.3	.02
Calcium,	27.3	Magnesium chloride	9.8	.57
Iron,	.0	Magnesium sulfate	60.8	3.54
Alumina,	1.8	Calcium sulfate	71.6	4.18
Nitrate,	.0	Calcium carbonate	9.5	.55
Nitrate,	12.4	Alumina	1.8	.10

Chlorine,	30.
Sulfate,	105.6
Silica,	9.8

Silica	9.8	.57
Bases	1.2	.07
Total	220.6	12.85

Frost Protection.

In extremely cold climates it is very necessary to provide protection against frost, especially at stations where but little water is used. An accompanying illustration shows method used to prevent frost troubles with a conical bottom tank on Canadian roads where the temperatures range as low as 50 deg. below zero. Fig. " A " shows an arrangement for operating the valve of the outlet pipe from below by a mechanism which is confined inside of the riser pipe. This does away with the overhead levers and fixtures. Fig. " B " shows an ice fender constructed over the top of the riser pipe to prevent ice from slipping down from the sides of the tank and damaging the valve and service pipes. Fig. " C " shows a heating arrangement to keep the ice from accumulating in the tank. A heating chamber is provided underneath the riser pipe by raising the bottom of the riser about 7 ft. leaving room for a stove. To confine the heat around the water contained in the riser pipe a two-ply wood frost casing of dressed and matched lumber with a layer of building paper between is built around the riser pipe. This frost casing is so constructed as to leave a 5-in. air space between the casing and the riser pipe. Large holes are cut in the lower part of the riser around the stove to allow the superfluous heat to pass around into the air chamber formed by the frost casing. The heat from the stove is also carried to the top of the tank through two 6-in. wrought iron pipes as shown in Fig. " C." The top of the tank is provided with an inside wood roof of dressed and matched lumber constructed similar to the frost casing, forming an air space under the steel roof to retain as much of the heat as possible.

Comparative Life of Wood and Steel Tanks.

The comparative life and value of wood and steel tanks has been the subject of much discussion, each type of tank having its more or less disinterested champions. This discussion has usually consisted largely of individual opinion or the quoting of obscure cases as examples of what might be expected of each type of tank.

While no doubt there are wood tanks in existence that will justify the strongest claims of the advocates of that type of tank, such cases can not be taken as an example of what can be expected of tanks constructed at the present time, for the reason that select tank timber is becoming more difficult to obtain year by year. Also the tanks cited as to long life of timber are smaller tanks than are being constructed today. Forty years ago a wood tank rarely if ever exceeded 20 ft. in diameter with 14 to 16 ft. staves while many of the modern wood tanks are 30 ft. in diameter with 18 to 20 ft. staves. The mechanical wear on a larger tank is undoubtedly greater than on a small tank and deterioration is more rapid accordingly. On the other hand it would not be consistent to attempt to base the life of a modern steel tank on the life of an iron tank as constructed 30 or 40 years ago, as corrosion will necessarily be greater with the steel tank. There are no examples of steel railway water tanks that may be quoted to show the extreme life of steel tanks, as they were not in general use previous to 20 or 25 years ago. In an attempt to arrive at some definite conclusion as to the comparative value of wood and steel tanks the following table has been prepared. The estimated life of each tank is given as 40 years which would probably be the extreme life of either tank.

The data regarding the wood tank are based on a clear heart red cypress with wrought iron hoops, creosoted pine frame and concrete foundation. The cost of the steel tank is based on a concrete price for the tank complete erected on a foundation furnished by the railroad.

The foundation in each case is figured on the basis of 60 yd. of concrete at a cost of $8 per yard. The freight rate is based on a haul of 400 miles on all material entering into the construction of the tanks except the sand and gravel used in the foundation, which is based on a haul of 50 miles. The insurance rate on the wood tank is based on 1 per cent per annum. The cost of painting the wood tank covers the wood tub, hoops, frost box and roof only for the frame being creosoted does not require painting. The cost of painting the steel tank is based on two coats of paint inside and outside every four years. The cost of the steel tank is based on 5-16 in. steel throughout.

Comparative Cost of 100,000 Gallon Wood and Steel Water Tanks.

Detailed Cost to Build and Maintain a 20-ft. by 30-ft. Tank on Wood Frame.

	Material and Labor.	Freight.	Material, Labor and Freight.	Estimated Life in Years.	Percentage of Total Value.	Maintenance.	Cost to Build and Maintain.	Capitalized Cost.
Foundation, .	$ 480.00	$42.50	$ 522.50	Perm.	18.70	None	$ 522.50	
Substructure,	600.00	44.32	644.32	25	23.00	$386.55	1,030.87	$268.46
Tank, ...	1,050.00	14.53	1,064.53	40	38.00	None	1,064.53	176.24
Ladders, ...	36.90	.95	37.85	10	1.35	113.55	151.40	60.17
Hoops, ...	250.00	7.18	257.18	15	9.18	685.14	942.32	238.13
Frost Box, ...	90.00	6.67	96.67	15	3.45	257.79	354.46	89.51
Roof, ...	125.00	6.55	131.55	10	4.70	394.65	526.20	209.14
Painting, ...	45.00	.40	45.40	4	1.62	408.60	454.00	210.67
Cleaning, ...	20.00	.....	....	1	.....	780.00	780.00	400.00
Insurance 1%	22.77	.....	....		.....	911.40	911.40	455.50
			$ 2,800.00			$3,937.68	$6,737.68	2,107.82

Detailed Cost to Build and Maintain a 100,000-Gallon Steel Tank.

Foundation,	$ 480.00	$42.50	$ 522.50	Perm.	15.26	None	$ 522.50	
Tank, ...	2,715.00	49.60	2,764.60	40	80.77	None	2,764.60	$ 457.71
Painting, ..	135.00	.80	135.80	4	3.97	$1,222.20	$1,358.00	630.62
			$3,422.90			$1,222.20	$4,645.10	$1,088.33

It will be noted that the capitalized cost to build and perpetuate a 100,000 gal. wood tank is $4,907.82, while the cost to build and perpetuate a steel tank of the same capacity is $4,111.24; this leaves quite a balance in favor of the steel tank, and indicates that the steel tank is more economical than the wood tank. Perhaps the most important point in favor of a steel tank with a conical bottom over the wood tank is that a great deal of the suspended matter is precipitated in the mud drum. This mud drum may be cleaned very readily without taking the tank out of service by simply opening the washout valve, while with the wood tank it is necessary to take the tank out of service at least once a year and more frequently where muddy water is used. The settling drum of the steel tank undoubtedly takes a great deal of the suspended matter from the water that can not be removed with a wood tank and the advantage of removing this matter through the washout valve of the tank rather than from the locomotives in the roundhouse is apparent. It would appear that there is but little deterioration in a steel tank where the surface of the sheets is always covered with water and it is quite possible that it would be necessary to paint only the inside upper sheets which are alternately exposed to the air and covered with water, every four years, it being necessary to paint the bottom and riser pipe only at longer intervals. This would reduce the cost of painting the steel tank from the figures given above.

C. R. Knowles,
A. A. Wolf,
O. M. Suter,
T. J. Stuart,
Jas. Dupree,
A. C. Sydell,
F. M. Case,
Committee..

APPENDIX.

Tanks Over 50 Years Old.

1836 Lancaster, Pa. Standpipe 5 ft. in diameter, 75 ft. high, erected in 1836, removed in 1903, painted each year outside, and every three years inside.

1857 Louisville, Ky. Standpipe 4 ft. in diameter, 195 ft. high, erected in 1857, still in existence but not in use since 1911, painted from time to time on outside; never painted on inside.

1867 Erie, Pa. Standpipe, size not given, erected in 1867, taken down in 1913, plates in good condition, enclosed with brick, never painted, either inside or outside.

Tanks Over 40 Years Old.

1869 Chicago, Ill. Standpipe at the Chicago Ave. pumping station, 36 ft. in diameter, 138 ft. high, erected in 1869, and taken down in 1911.

1870 L. & N. R. R. Four iron tanks were built on the New Orleans division in 1870, the tanks being 8 ft. in diameter and 22 ft. high, with a capacity of about 22,000 gal. These tanks were reported in good condition in 1914. The tanks are emptied every two years and washed on the inside with a coating of cement, the outside is painted every two years.

1871 Rome, Ga. Standpipe 20 ft. in diameter, 80 ft. high, bricked up on the outside, has never been painted on the inside since erection. This standpipe was in excellent condition in 1914 and is kept full of water constantly, as it is used principally for fire purposes.

1872 Milwaukee, Wis. Standpipe 4 ft. in diameter, 125 ft. high, erected at the North Point pumping station in 1872. Up to 1914 the standpipe was painted about five times since its erection. The interior has been painted inside to the water line only, this water line being maintained at a point never lower than about 50 ft. from the top.

1873 New Bedford, Mass. Standpipe 5 ft. in diameter, 63 ft. high, erected in 1873. This standpipe is enclosed in an ornamental brick tower, and has never been painted either on inside or outside. It has not been in service for some 20 years.

1873 South Bend, Ind. Standpipe 6 ft. in diameter, 225 ft. high. This standpipe has been painted at intervals of five or six years and is apparently in very good condition at this time.

1873 Toledo, Ohio. Standpipe size not given, erected in 1873. The inside of the standpipe has been painted once only since erection and the outside seven times. It is in fair condition.

1874 Harrisburg, Pa. Standpipe, size not given, erected in 1874, and removed in 1914. The standpipe was never painted on the inside since erection. It was incased in brick with a special staircase around the outside. The portion of the standpipe which was exposed around the staircase was painted every few years.

1874 Columbus, Ohio. Standpipe 10 ft. in diameter and 100 ft. high, erected at the Ohio penitentiary in 1874. It has been painted at intervals of every two or three years.

1875 Sandusky, Ohio. Standpipe 25 ft. in diameter, 180 ft. high, erected in 1875. It has been painted every year or two both inside and outside. The present condition of the standpipe is good.

Tanks Over 35 Years Old.

1878 Uvalde, Texas. Standpipe 12 ft. in diameter, 100 ft. high, erected in 1878. It has been painted outside every four or five years, and four times on the inside. It is in good condition at present.

1878 Little Rock, Ark. Standpipe 20 ft. in diameter, 150 ft. high, erected in 1878. It has been painted both inside and outside on an average of every three years.

1878 Millville, N. J. Standpipe 12 ft. in diameter, 132 ft. high. It was painted on the inside shortly after being erected and has never been painted since. This standpipe is in first class condition both inside and outside.

1878 Nantucket, Mass. Elevated tank 24 ft. in diameter, and 15 ft. high, erected on a 27-ft. tower, built of 9 cast iron columns and wrought iron I-beams. This tank was erected in 1878 and was taken down in 1908. It was in good condition except part of the floor where it was imperfectly supported by the floor beams. It was painted annually inside, and about once in five years outside. The lower half of the side sheets were much pitted, but on the bottom but little. It was replaced by a larger standpipe in 1908.

1879 New Orleans, La. Standpipe, size not given, erected in 1879 and removed in 1908. Up to the time of its removal this standpipe was painted twice on the outside, with no record of having been painted on the inside.

1880 Greenwich, Conn. Standpipe 80 ft. in diameter, 35 ft. high, erected in 1880 or prior to that time. The tank has been painted three times since erection, both inside and outside. It shows some pittings, which are for the most part in the 20 ft. and 25 ft. sections. This is accounted for on account of this being alternately covered with water and exposed to the air more than any other section.

1880 Burlington, Vt. Standpipe originally built 20 ft. high and 30 ft. in diameter in 1880. It was raised to 35 ft. high in 1890. It was found badly corroded in 1894 and was painted inside and outside. It is now painted every two or three years with asphaltum.

1880 Brockton, Mass. Standpipe 59 ft. in diameter and 61 ft. high, erected in 1880 and taken down in 1911. The standpipe was painted inside and outside every three years while in use. The plates were in excellent condition when the tank was taken down.

Tanks 30 Years and Older.

1881 Allentown, Pa. Standpipe 7 ft. in diameter, 75 ft. high.

1877 Belvidere, N. J. Standpipe, size not given, erected in 1877, removed in 1909.

1881 Brooklyn, N. Y. Standpipe 20 ft. in diameter, 102 ft. high, erected in 1881 for the Flatbush Waterworks Company. It has been painted six times since its erection and is apparently in first class condition.

1882 Winona, Minn. Standpipe 4 ft. in diameter, and 210 ft. high, erected in 1882. It has been painted outside three or four times. The steel is somewhat pitted but still in good condition. It has been full of water constantly. Unable to state the condition on the inside.

1882 Philadelphia, Pa. Standpipe 5 ft. in diameter, 153 ft. high, erected in 1882. No interior examination has been made for some years, but the outside is in excellent condition.

1884 Brookline, Mass. Standpipe, size not given, erected in 1884.

Painted at intervals of three years both inside and outside. The standpipe is in very good condition.

1885 Kennett Square, Pa. Standpipe, size not given, erected in 1885. It is in a good state of preservation. It has been painted frequently on the outside but never on the inside.

Tanks 25 Years and Older.

1886 Milwaukee, Wis. Standpipe 5 ft. in diameter, 150 ft. high. It has been painted twice since its erection and is now being painted at intervals of five years.

1887 Newark, N. Y. Standpipe 18 ft. in diameter, 80 ft. high, erected in 1887. It was painted two years ago inside and outside and was found in good condition except somewhat pitted.

1887 Lawrence, Kans. Standpipe 20 ft. in diameter, 105 ft. high. It is occasionally painted with graphite paint. It was not painted on the inside when first erected but was painted about ten years later with asphaltum. It has never been painted on the inside since. The present condition is good.

1888 Burlington, N. J. Standpipe 20 ft. in diameter, 100 ft. high, erected in 1888. It has been painted both inside and outside every two years and is in good condition.

1888 Sedalia, Mo. Two steel standpipes 15 ft. in diameter, 127 ft. high. They were erected in 1888; painted with graphite and oil on the outside and protected on the inside by floating a barrel of black oil on the water as the standpipe was filled.

1888 Grand Rapids, Mich. Standpipe 20 ft. in diameter, 100 ft. high, erected in 1888.

1889 Grand Rapids, Mich. Standpipe 30 ft. in diameter, 75 ft. high, erected in 1889. Both standpipes are apparently in good condition. They have been painted three times inside and outside since erection.

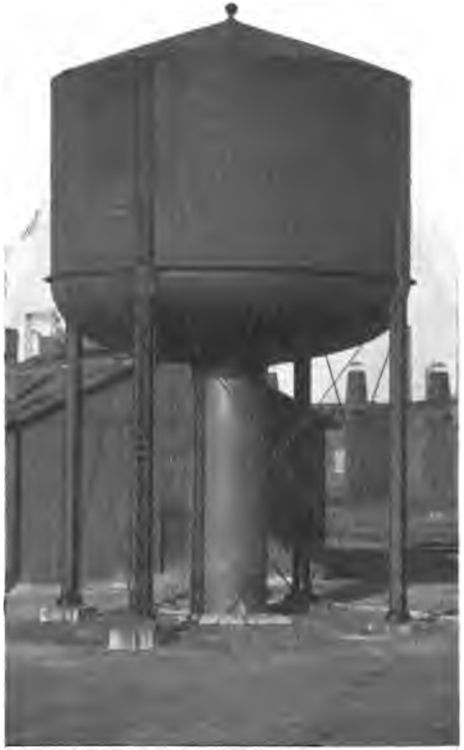
1888 Morristown, N. J. Standpipe 35 ft. in diameter, 20 ft. high, erected in 1888.

1889 Natchez, Miss. Standpipe 12 ft. in diameter, 150 ft. high, erected in 1889. It was painted inside and outside in 1901, 1906 and 1912, the condition being fairly good. There is considerable pitting in the interior above the elevation of 100 ft.

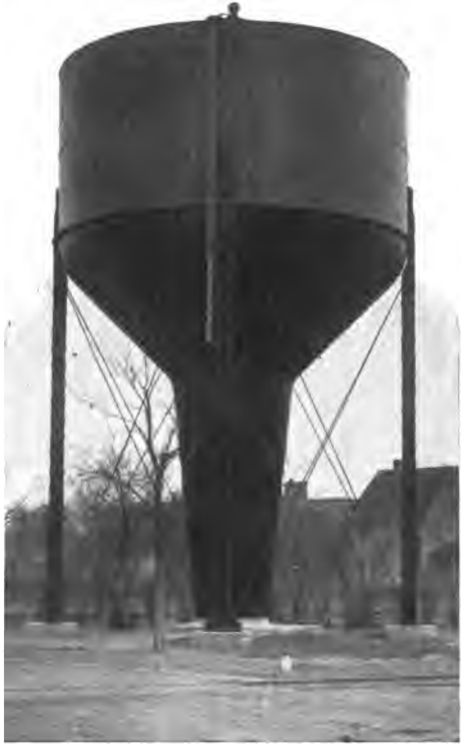
1890 New London, Conn. Wrought iron tank 25 ft. in diameter, 26 ft. high, erected on a tower 68½ ft. high. It has been painted every three years inside and outside and is now in good condition.

1890 Oil City, Pa. Two iron tanks 30 ft. in diameter, 12 ft. high, erected in 1890. Some scale has been scraped off these tanks but not to any appreciable extent. They are painted inside and outside with pure lead.

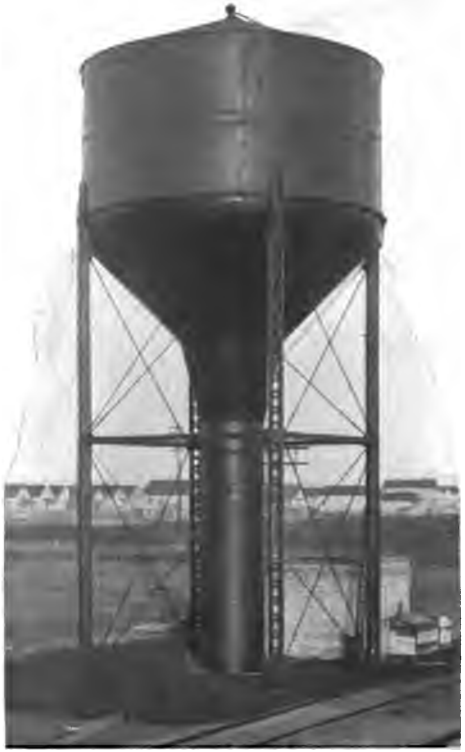
1890 Somersworth, N. H. Standpipe 20 ft. in diameter, 70 ft. high. It is painted inside and outside every three years.



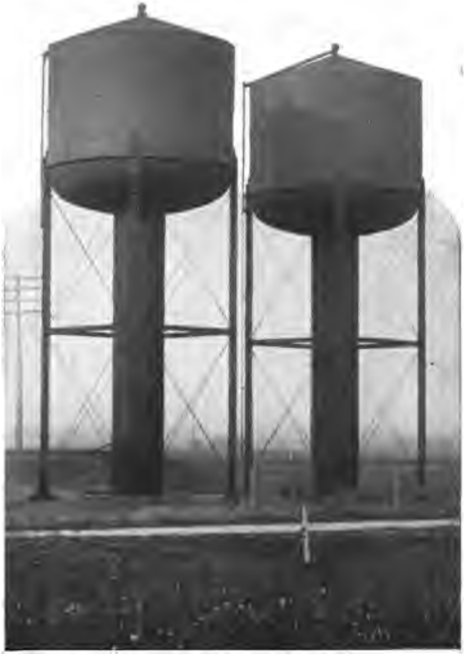
Standard Elliptical Bottom Tank, Chicago, Burlington & Quincy R. R., Ottumwa, Iowa. Capacity, 100,000 Gal. Height, 20 Ft. to Bottom.



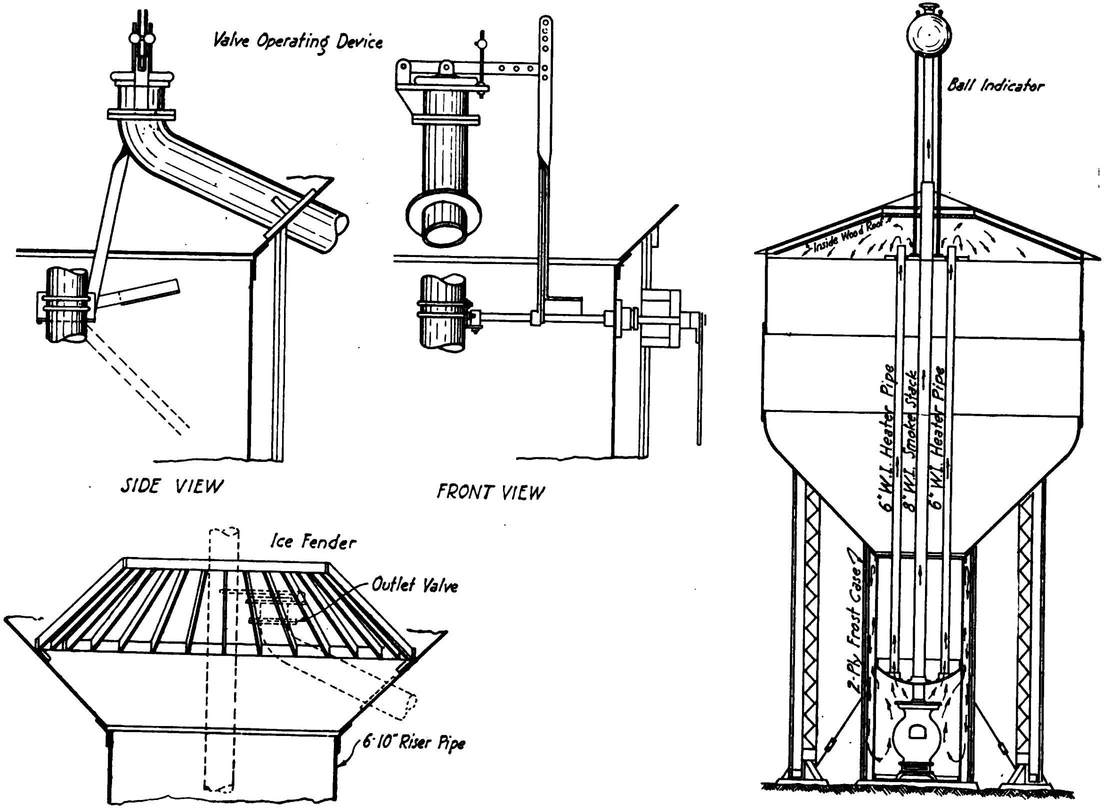
Standard Conical Bottom Tank, Chicago & Northwestern Ry., Ames, Iowa. Capacity, 100,000 Gal. Height, 20 ft. to Bottom.



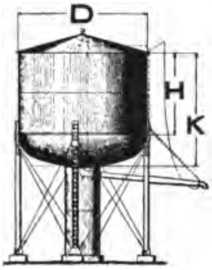
Two Panel Conical Bottom Tank, Chicago & Western Indiana R. R., Chicago, Ill. Capacity, 100,000 Gal. Height, 32 Ft. to Bottom.



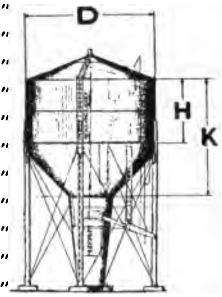
Two Panel Elliptical Bottom Tanks, Pennsylvania Lines West of Pittsburgh, Schererville, Indiana, 50,000 Gals. Each. 32 Ft. to Bottom.



Valves and Apparatus for Heating Steel Tanks.



Capacity Thousand Gallons	Elliptical Bottom			Conical Bottom		
	D	H	K	D	H	K
15	15'-0"	9'-0"	12'- 9"	15'-0"	8'- 0"	13'- 7"
20	16'-0"	11'-0"	15'- 0"	16'-0"	9'- 9"	15'-11"
25	17'-6"	11'-0"	15'- 4"	17'-6"	9'-11"	16'-11"
30	18'-6"	12'-0"	16'- 7"	18'-6"	10'-10"	17'- 5"
35	19'-0"	13'-4"	18'- 1"	19'-0"	12'- 3"	19'- 1"
40	20'-0"	13'-9"	18'- 9"	20'-0"	12'- 6"	19'-11"
50	22'-0"	14'-0"	19'- 6"	22'-0"	12'- 7"	21'- 2"
60	24'-0"	14'-0"	20'- 0"	24'-0"	12'- 2"	21'-11"
65	25'-0"	13'-8"	19'-11"	24'-0"	13'- 8"	23'- 5"
70	25'-0"	15'-0"	21'- 3"	25'-0"	13'- 4"	23'- 8"
80	26'-0"	16'-0"	22'- 6"	26'-0"	14'- 3"	24'- 2"
100	28'-8"	16'-0"	23'- 2"	28'-8"	14'- 2"	25'- 7"
150	34'-0"	16'-6"	25'- 0"	33'-0"	15'- 9"	29'- 8"



Dimensions of Standard Steel Railway Water Tanks.

Three 150,000 Gal. Steel Tanks, Chicago & Northwestern Ry., Proviso, Ill.

Old Tank at Vicksburg, Miss., with Square Iron Hoops.

Metal Tank at the Shops of the C. R. I & P. Ry., Chicago. This Tank is built of 3-16-inch Metal. It was Erected in 1867, and is Still in Perfect Condition.

DISCUSSION.

(Subject No. 3, Railway Water Tanks.)

J. N. Penwell:—The subject of tank hoops has been up a number of times and was quite thoroughly discussed when the subject was up for report and discussion at the 1910 convention at Denver. I believe I stated at that time that if I could get good flat wrought iron hoops I would prefer them to any other. We had started to use a round hoop at that time and were unfortunate with them because we bought steel. Some of them broke in two while being put on with the aid of a 16 in. monkey wrench, simply in drawing them up to make the tank tight enough to hold water. We then adopted a half round hoop and we specified wrought iron. The firm from which we purchased these hoops is perfectly willing to furnish wrought iron if we specify it. If we do not they will furnish the cheapest thing on the market on account of competition. We have had no trouble with the half round hoops. They conform more readily to the shape of the tank than do the round hoops. I prefer the half round hoops made of wrought iron, but have no use for any kind of hoop made of steel.

J. Dupree:—The chairman makes this statement in the report referring to the half round hoops: "The principal objection that could be offered to this type of hoop is, that it is much harder to apply than either the flat or round hoop, on account of the difficulty in making it conform to the circle of the tank. The rigidity of this hoop is also objectionable from the fact that when the staves are softened by partial decay, there is a tendency for the hoops to straighten out and throw the tank out of round, especially if the tank is empty or only partly filled with water." This is not correct; the oval hoop will conform to the round tank just as well as a flat one, except for the last two feet at the ends which should be slightly bent to conform to the shape of the tank. A little experience will teach one how tight to draw up the nuts on the bolts. The bolts should not be overstrained in tightening the hoops. Round hoops must all be shaped at the factory before sending out. They are difficult to put on. I prefer wrought iron hoop material in any case. The same will apply to wrought iron and steel for metal tanks.

E. R. Wenner:—I am located on a division on the Lehigh Valley where I have known of wooden tanks being in use for

25 years, and they were up for at least 10 or 15 years previous to the time I first saw them. Some of these tanks are still in service in fair condition and the flat wrought iron hoops are apparently as good as the day they were put on. I am willing to take my chances of their lasting 25 years more. We also have flat steel hoops in use on this same division and had two tanks fail where the hoops had been on less than 8 years. After this experience we abandoned the use of steel hoops. I made up my mind that we ought to get half round hoops which I then specified and in two cases, I think, we have received them. I consider them an excellent hoop. They conform to the tub just as easily as the flat hoops provided they are bent to shape for about 2 ft. at the ends next to the lugs. We have been furnished some round steel hoops which are formed before leaving the factory. They are more troublesome to apply than either the flat or half round hoops. I believe that we should get away from using steel for hoops as nothing short of wrought iron will last. When we first received the flat steel hoops I was of the opinion that they would probably be all right but I soon changed my mind after we had the two failures which I mentioned.

C. R. Knowles:—It is true that with a poorly framed tank it is necessary to draw the hoop tighter than with well fitting wood work, but, in any case, the round hoop will have a tendency to crush into the staves for the reason that it has such a small bearing. No hoop will properly serve its purpose unless it has sufficient bearing. Round hoops are always of comparatively small diameter, and when they are drawn up to make a tank tight they crush the wood more or less.

G. W. Rear:—A great deal of the imbedding of a round hoop in the staves is caused by the attempt to make a poor tank water tight. It is often the case that a round hoop is over-strained to make the tub tight.

J. N. Penwell:—Mr. Wenner referred to the long life of wrought iron hoops. I might cite an instance where I took down a wooden water tank which had wrought iron hoops that had been on for 28 years. The hoops were perfectly good and after cleaning them we stored them away for future use. The following year we had some steel hoop failures on a tank that had been erected 11 years before and we used the 28-yr. old hoops to replace the steel hoops that failed. Two years ago we tore this tank down and if I am not mistaken we have a few of those old hoops laid away to be used for the third time. I realize, of course, that we are unable to get as good a quality of wrought iron today as we did 30 or 40 years ago, but I prefer that which we can get to steel.

C. R. Knowles:—We are all agreed upon the subject, at any rate, that iron is better material for tank hoops than steel, regardless of the shape of the hoop. I am of the opinion that the quality of the material entering into the construction of the hoop is what we should consider rather than to try to remedy matters by resorting to shapes that will possibly add a few years to the life of the hoop but at the expense of the tub. An abundance of evidence has been produced to prove that a set of properly designed flat wrought iron hoops will give better service and a longer life than any hoop made of steel regardless of the shape. The essential thing is to insist upon genuine wrought iron and if such can be had the shape does not materially affect the life of the hoop and need not be considered only as affecting the timber. The fact that a hoop ¼ in. thick will conform more readily to the shape of the tub and is easier to apply than a hoop of any other section is obvious and needs no argument.

The Secretary:—I would call the attention of the last speaker to the fact that one of the principal objections to the flat hoop is that it covers such a large area of the wood. As long as we had hoops of genuine wrought iron and the best quality of lumber the flat hoops answered the purpose very well. But as the lumber got poorer, rotting under the hoops, and steel hoops were substituted for iron, the flat hoop was not satisfactory and had to go. It proved too expensive to remove the steel hoops often enough to prevent them from rusting to the danger point. The wide flat hoop and the round hoop are both objectionable for various reasons, made of any kind of metal, and that is the reason why the oval design came into use. Since the quality of the metal we get these days, even if wrought iron be specified, is not satisfactory for flat hoops and round hoops are decidedly objectionable for tanks of large capacity I am quite in favor of the oval hoop. Nearly everyone who has used them favors them over any other style.

J. Dupree:—I would call the attention of our members to a paper printed by a paint firm in Ohio whose chemists have published some interesting discussions on the subject of corrosion. We all know what happens to steel when exposed to dampness in the immediate vicinity of railroads when coming in contact with the acid fumes from locomotives.

W. E. Alexander:—Our tanks are all built of wood. The hoops prove much the same as represented in this discussion. The flat iron hoops (which must have been made of good iron) have been on some tanks for 22 years and seem to be as good as ever. We had steel hoops which gave out within six years from the time they were erected. Three hoops fell from one tank, but luckily the tank did not collapse, as they came off midway between the top and bottom, allowing the water to gush out and relieve the pressure. The tank was full at the time the hoops broke. We have had to renew the hoops on a number of our tanks because they rusted and some broke. We have had to go over our tanks, take off the hoops and examine them and put a piece in here and there. While one piece was found to be badly pitted the remainder of the hoop may have been in good condition. We would perhaps not have to patch more than two or three places in an entire tank.

Several spoke about the round hoops having to be formed before being put on. This is true. We use round hoops for applying between flat hoops where there is danger of the flat ones breaking, and where we wish to remove the flat hoops for repairs, cleaning and painting. In this way we can keep the tank in service all the time.

E. T. Howson:—Mr. Alexander's comment about hoops bursting, calls to mind a practice on one road of removing, inspecting and replacing the hoops on each tank every two years simply as a precaution against failures.

The Secretary:—Seems to me this would prove quite expensive. A staging has to be built to do the work and it requires some time to remove all the hoops and place them back again. One could afford to pay a pretty good price for wrought iron hoops if they could go 20 years or more without removal as was the case with the earlier tanks mentioned. I know of tanks on the Northwestern road that had hoops in service for over 20 years without being removed, and when the tanks were taken down the hoops were laid aside to be used again. I think that most of you will agree with me that it is pretty expensive to remove tank hoops every two years.

C. W. Wright:—My predecessor on the Long Island replaced the hoops on a number of tanks with ¼ in. by 4 in. galvanized iron riveted hoops using a clamp block on them. He put them on in three parts, and everything went all right until early last fall when a 50,000 gal. tank burst open on a very mild night. We examined the hoops, expecting to find one which had a bad spot in it that had been covered with the galvanizing, but we found that 70 per cent of the malleable iron lugs had flaws. In some of them the entire bolt had broken away from the seat it was fastened to. We found some few with the bolts broken, but that was to be expected on account of the bottom hoop being the one that let go. The remedy we applied was to increase the number of the hoops on the tank 50 per cent. I have not heard of any other member having had experience with broken lugs.

E. F. Gardner:—The standard tank of the Erie is a 50,000 gal. pine or cypress tank with round hoops, supported on a 26-ft. reinforced sub-structure and foundation. We think that a concrete sub-structure is better than anything else for durability and it is not very much more expensive than wood. We had much trouble with flat hoops which were constantly giving out. I have had the same experience that one gentleman here had of renewing newer hoops with old ones taken off old tanks. I personally have had the assurance from certain firms that manufacture ingot iron that they can furnish a very good quality of iron at the present time.

E. K. Barrett:—The standard hoops on the Florida East Coast are 3-16 in. by 4 in. and 3-16 in. by 5 in., galvanized. Most of our tanks are 50,000 gal. capacity and have been built from 14 to 16 years. The only trouble we have had with them had been due to the failure of the lug bolts. We use a patent lug, and the trouble has been that the bolts occasionally rust out in the lugs which causes a failure of the hoop. I would like to know if any other member from the south has experienced the same trouble or whether it is due to our being located along the sea-coast?

The Secretary:—Probably due to a poor quality of iron.

J. Dupree:—What size bolt do you use?

E. K. Barrett:—A ¾ in. by 18 in. bolt.

J. Dupree:—A ¾ in. bolt is too light. Make the hole larger and use a 1⅛ in., or 1¼ in. bolt and you will have no more trouble.

C. R. Knowles:—In this discussion the members seem to be under the impression that wrought iron and steel are two entirely different metals, but such is not the case. Wrought iron and steel are both 93 per cent to 98 per cent iron; the difference in the two is merely in the process of manufacture and in the remaining elements. Members have mentioned wrought iron, steel and ingot iron hoops. As a matter of fact the ingot iron manufacturers are not able to furnish hoops to our specifications when we specify genuine wrought iron nor is any other manufacturer or dealer in hoops. They can not give you your requirements unless they make a special order of perhaps several car loads.

Flat hoop failures have resulted on account of the hoops being made of steel. It does not require an elaborate equipment to tell whether one has steel or iron hoops. One can readily prepare a sulphuric acid bath and with a little experimenting (by dipping the end of the hoop in it) can soon decide if the metal he is testing is iron or steel.

R. C. Sattley:—This association has always been afraid to put out reliable cost data on anything. Every railroad in this country is furnishing costs. If we had started in 4 or 5 years ago to analyze the cost of all of these things, we would have something we could give the government now, instead of starting in and trying to get together a lot of cost figures in a few months.

The President:—Mr. Sattley, the study of costs is one of our subjects.

R. C. Sattley:—I was only speaking about this one subject; I want to express my appreciation to the committee for touching on costs.

C. R. Knowles:—We need not be afraid of these costs because they have been submitted to the railroad valuation committee and no objections have been raised.

A. S. Markley:—The contract price for a 100,000 gal. steel water tank erected in Dec. 1912, on a 20-ft. tower, with mud tube, complete above foundation was $2,850. Foundation, of concrete, cost $300. Total, $3,150. Another steel tank or tower, 24 ft. diam. and 45 ft. high, resting on a bed of crushed stone 18 in. thick, cost as follows: Tank, $1,900. Foundation, $75. This tank has an available capacity and water is delivered by means of a crane or standpipe.

A steel tank for locomotive water supply with a conical bottom on 30-ft. tower, in service on the Chicago & Eastern Illinois railroad since 1900, is still in good condition as far as I know, although it is located on another division. Many of us can recall locomotive tender tanks that have been in service 35 to 40 yrs. with the original sides still in service, while the bottoms may have been renewed on account of wear and rust where it came in contact with the frame. So the water tower which I referred to will, I believe, rust out first where it rests on the crushed stone foundation. Tanks mounted on towers are free from such action.

The Secretary:—It is quite probable that the locomotive tanks which Mr. Markley refers to as being 35 to 40 yrs. old may have been built of iron instead of steel. I know of steel tanks in recent years that became so badly pitted that they had to be taken out of service in less than half the time mentioned by Mr. Markley. Of course, the quality of the water may have considerable to do with it.

C. R. Knowles:—Referring to the cost of steel tanks; Mr. Markley is probably right. The tank represented here is built of 5-16 in. steel, but we can reduce the cost considerably by using lighter plates and tower. We find that $8 per yard is about as cheap as we can build concrete in this type of foundation. A 100,000 gal. tank should have 50 or 60 yd. of concrete for a foundation, but this may vary according to local conditions.

Some prefer wood tanks to those of steel. If we could secure good wooden tanks I would perhaps prefer them also, but we can not get a wooden tank today that can be put in competition with a steel tank as the figures will show. With wooden tanks we are limited practically to 100,000 gal. capacity. In such tanks it is not practical to get lumber for the bottom without splicing the long pieces. It is not so much the question as to whether we prefer the steel tank or not, but we have to take it because it is difficult to secure other material except concrete, and concrete tanks have not yet come into general use.

P. J. O'Neill:—I want to correct one statement made by Mr. Knowles. The New York Central has 36 ft. by 20 ft. 125,000 gal. wooden tanks. They are not desirable, but the limit as to what one can build in a wooden tank has never been reached, although the limit of desirability has been reached in a 100,000 gal. tank.

C. R. Knowles:—The economical limit is what you mean?

P. J. O'Neill:—No, I do not agree with you in that respect. I built this 125,000 gal. tank because I could build one tank cheaper than two, but I found it was difficult to make repairs. When I had two, I could take one out of service for repairs and use the other.

C. R. Knowles:—Our comparative figures show that when one reaches the 100,000 gal. tank, he has reached the economical limit of a wood tank, although one may build a wood tank cheaper.

P. J. O'Neill: What I meant was that I could build a single tank holding 125,000 gal. for less than I could build two 75,000 gal. tanks. Of course I had to use heavier construction all the way through. The posts are two 7 in. by 14 in. timbers, put together with bolts, and the caps on top of the posts are two 7 in. by 14 in. timbers with two 7 in. by 14 in. corbels over the center posts. After making due provision for sustaining the greater weight, I found no more trouble in holding up the larger tank than the smaller one.

C. R. Knowles:—Some of the creosoted frames under our wooden tanks have been painted rather by accident than by design, and the result was a variegated appearance after a few days of hot weather. Our standard color for tanks is box-car red, and after the paint comes in contact with the creosote oil it is difficult to properly describe the color. After a creosoted frame has been weathered for a time I am of the opinion that it looks better than when new.

G. W. Rear:—During the past few weeks I had several metal tanks cut apart which had been up 11 to 15 years. All of these tanks were badly pitted on the inside. One had not been painted on the inside when it was put in service and the other tanks had. There was no difference between the condition of the metal inside the tank that had not been painted originally and of those that had been painted. In cutting these tanks down I found the 2 or 3 top sheets in good condition but the sheets lower down in the tank were badly pitted where the water had been constantly in contact with them. There was no corrosion or pitting that would have caused the tanks to fail; the most that could have occurred would have been leaks, and the leakage would have been apparent long before there would have been any possibility of the tanks rupturing. The pitting was in small holes, some of them 2 in. in diameter, but they were quite deep.

We have cut down other tanks which have been built the same length of time and found very little pitting in them, because of the character of the water in them. Anyone knows that certain waters will corrode steel much faster than others.

It is a fact that we should pay more attention to the painting of the tanks. There is only one time to paint a tank and that is when it is new, because no matter if we say we ought to paint them at intervals of one, two or three years, they will not be painted. I asked one of our supervisors once how often he painted the tanks, and he said, " Every two or three years." Then I asked him to look it up definitely and let me know how many times he had painted the tanks on that division, and I found it was every 14 years. It is impossible to paint water tanks on the inside, because you have got to dry them out before you paint them. How are you going to do this? It means a delay of as much as two weeks to dry a tank out sufficiently to give it a good job of painting. It may be that we can find some kind of enamel paint or asphalt coating that we can apply on the inside of these tanks when they are manufactured that will make a good job and avoid the necessity of painting them for a great number of years.

A. S. Markley:—There is no paint or other preparation made which will resist the corrosion on the interior of steel tanks.

C. R. Knowles:—I am surprised that the pitting which Mr. Rear mentioned was found on the bottom of the tank, because from the limited experience I have had with steel and iron tanks, this pitting has occurred largely in the top sheets where they have been alternately exposed to a wet and dry condition. It is quite probable in the case mentioned that there were corrosive elements in the water that had a tendency to concentrate on the bottom of the tank or that the tanks were allowed to remain empty for some time.

The importance of properly painting steel tanks can not be over-estimated, and, as Mr. Rear says, applying the paint to the interior of the tanks without keeping them out of service for several days is one of the problems we have to contend with. We are proceeding on the theory that where the metal is continually covered with water the corrosion is not as rapid as where the metal is alternately wet and dry. This will, of course, not be taken for granted, but it is the intention to watch the interior of the tanks closely and unless undue corrosion takes place the upper sheets only will be painted at intervals of three or four years, which can be done by keeping the water level down and avoid taking the tank out of service.

G. W. Rear:—The tank I spoke of has a flat bottom and might have been affected to a great extent by the amount of water regularly carried in the tank. I have no way of finding how much was usually carried, but in a good many places we are rather short of water, and the chances are that there was not much in the tank and that the upper 5 or 6 ft. had never had any water in it in the lifetime of the tank, or very little. We are putting the tanks up again and using the three upper sheets and scrapping the three lower sheets and putting in new bottoms.

E. R. Wenner:—We have two 100,000 gal. steel tanks on our division which have been in service about 4 years. We thought they ought to be painted and about two weeks ago we painted one of them. I found the same condition most of you have found, that the down leg, the conical part of the bottom and the sides of the tank were all right, except that the top sheet or two showed just a slight indication of scale, not enough to cause any alarm, but enough to indicate that the trouble begins where the level of the water varies. Of course the objection to painting a steel tank where there is only one, is the abandonment of the water service at that point for the length of time it requires to paint it. I feel it is absolutely no use trying to paint the inside of a tank in a few days, therefore I made arrangements with our people to decrease the tonnage a little between water stations east and west of the point where the tank was out of service for the ten days required to clean and paint the tank and to dry it again ready for use. We applied two coats of paint. I feel that it now has all the protection we are able to give it, but such a job can not be well done in less than ten days.

A. H. King:—In discussing the subject of wrought iron, it seems to me that one point has been overlooked; that is that the wrought iron we are getting today is not as good by any means as that which we got 40 years ago. It is really little better than steel. The iron we got 40 years ago withstood corrosion, very well. I think that is one of the important reasons why some of the older tanks last so much better than those being built today.

J. N. Penwell:—I have not had much experience with steel tanks, but I want to tell of one little experience we had with a tank getting pitted that had been up three years. We began to feel alarmed about its condition and started to paint it a few years ago. We found that the worst place was where the water was rising and falling, where the air came in contact with the tank at times while at other times it was under water. There was considerable mud in the bottom of the tank and I expected to find serious trouble when we removed it, but the action of the chemicals in the water was such as to preserve it under the mud and the steel was perfectly bright, not even being corroded. Above that point we found some damage, but nothing like what I had anticipated.

When we get into the construction of steel tanks, the chemicals in the water have a great deal to do with their life. I doubt if it would be profitable to build a steel tank and use the water that some of the gentlemen have to contend with, although in other places the water would tend to preserve the steel and a tank would stand for generations. The painting of the inside of the tank is a serious thing and, as one gentleman remarked here, we can not paint one in three days; if we can not get the tank for ten days, we might just as well save our paint.

J. Dupree:—The action of frost is much greater in a steel tank than in a wooden one. Three or four inches of wood is somewhat of a protection in freezing weather while the thin plates of steel do not resist the cold at all. Water will freeze in both wooden and steel tanks but far more readily in the latter.

W. E. Alexander:—We are located in a cold climate, being in Maine, and we have had some wooden tanks erected which were termed frost-proof. They were provided with a false floor with an air space, lined with matched boards and a covering of tarred paper. While this was to protect the bottom of the tank from the cold it was a great detriment to the tank because it rotted out very soon. We had to renew the bottom and the staves and the tank is now in good condition.

G. W. Rear:—While it may be foreign to the subject I notice that this report terms what we call a water column, a penstock. According to the catalogs of the firms which sell this apparatus it goes by all kinds of names. It seems that some standard name ought to be adopted in our reports. It seems to me that we ought to adopt the same name as the manufacturers call it by, namely, a water column. I think that the majority of the railroads term it a water column and I believe the American Railway Engineering Association has adopted that term.

C. R. Knowles:—There seems to be no uniformity in the names applied to the device for delivering water to the locomotive tender even among the manufacturers; for example, the U. S. Wind Engine and Pump Co. and the American Valve and Meter Co., call them " Water Columns "; Fairbanks, Morse & Co. call them " Standpipes," and the T. W. Snow Construction Co. call them " Water Cranes," while in this paper they are referred to as " Penstocks." None of these terms are strictly applicable to a device of this kind. There are three definitions of " Water Column " in the dictionary, seven of " Standpipe," two of " Water Crane " and five of " Penstock." The only definition given as applying to the device under discussion is that of " Water Crane," which is defined as, " A crane for turning water from a railway tank into a locomotive tender." The term " Penstock " is used to designate a conduit to a water wheel gate and also to designate the gate itself, and as the device under discussion is a combination of conduit and gate, the term " Penstock " is used. One of the definitions of a " Water Column," is, " A column up which the supply water for a water crane passes " and would appear to apply only to this part of the device. Also the term applies to a boiler fixture and to a column of water and in general usage could but be confusing. The term " Penstock " has the advantage of being but one word and is not in common use on railroads, hence its use in this paper.

F. E. Weise:—The appliance under discussion is known by several different names which in most cases are the ones adopted by the manufacturers. All of the names are applicable and easily accounted for. One man saw in it a pipe, standing erect beside the track, and he called it a " standpipe." In fact the original device was a piece of pipe shaped like an inverted L with a valve, somewhere along the pipe where it could readily be reached, and a rubber hose attached to the end. To another man this standing pipe suggested a column and because it was used for conveying water he called it a " water column." Another saw in it the shape of a crane, and not only is it like a crane in shape but the upper or horizontal portion revolves like a crane, and he called it a " water crane."

The term " standpipe " is used more generally in connection with an elevated tank or reservoir built for the purpose of supplying water under pressure (see committee report on " Concrete Tanks "), and if this name is applied to the apparatus there might be at one and the same water station two standpipes, one for conserving the water supply, the other for delivering water to the locomotive tender and the former might be supplying water for the latter. In this case there would be a confusion of terms.

The name " water column " is in more general use in connection with boilers and does not correctly apply. The word " penstock " was used by the committee in an effort to use a designation that would not be confused with other appliances in general use, and the reason for the suggestion is plain. A " penstock " is defined as " a close trough or tube for conducting water, as to a waterwheel, or for emptying a pond." There is no good reason why it should not be used in this connection and it is more applicable than either of the two expressions " standpipe " or " water column."

It is my opinion that the designation " water crane " is more fitting than the others because it not only names but it describes the appliance and gives to it a title entirely distinct from other railroad structures. The word " crane " was at one time applied to " a siphon, or bent pipe, for drawing liquids out of a tank," and the application is quite evident. Webster defines a water crane as " an apparatus for supplying water from an elevated tank, as to the tender of a locomotive," but he gives no definition of standpipe or water column that can be directly applied.

It is doubtful whether a change in the present custom could be brought about or would be desirable. The road that has adopted the product of one manufacturer as a standard will adhere to the name which he has applied but where several different makes and types are in use a general term such as " water crane " seems desirable.

Mr. Knowles:—I submit herewith some discussion on the stability of unanchored tanks, born of our experience with the hurricane of September 29, 1915.

The question of the stability of unanchored railway water tanks has been the subject of more or less discussion from time to time, there being advocates both for and against the practice of anchoring the tower of the tank to the foundation. Some authorities have claimed that in all instances the tower should be firmly anchored to the foundation, while others have contended that anchorage was unnecessary with railway water tanks 24 ft. to 30 ft. in diameter on standard twelve-post towers 30 ft. high and under.

The fact that three unanchored standard 20 ft. by 30 ft. wooden tanks on the Louisiana division of the Illinois Central withstood the hurricane of September 29, 1915, with no more damage than the unroofing of one of the tanks, would appear to support the latter theory, that anchoring the footing of low frame tanks is an unnecessary expense.

The tanks in question are located at Government Yard, New Orleans, La Branch, and Hammond, La. The tower of the tank at New Orleans is a twelve-post steel tower well braced and having a floor system of " I-beams." The total height from the top of the foundation to the bottom of the tank is 20 ft.

The tower of the tank at La Branch is constructed of 12 in. by 12 in. creosoted posts, each bent being braced with two sets of 6 in. by 6 in. braces, the floor system consisting of 12 in. by 12 in. caps and 4 in. by 14 in. floor joists, the total height from the top of the foundation to the bottom of the tank being 20 ft.

The tank at Hammond, La., is on a 28 ft. tower of the same type of construction as the one at La Branch.

The storm began on the night of September 28th with rain and a gradually increasing northeast wind. By 7 o'clock on the morning of the 29th the wind had increased to a gale of forty miles per hour, and during the day both wind and rain increased in intensity until between 5:00 and 5:30 o'clock P. M., when, according to the weather bureau reports, there was a sustained wind velocity of over 80 miles per hour and velocities up to 120 and 130 miles per hour during the hardest gusts, with a minimum barometer reading of 28.11 in. About 6:00 o'clock P. M. there was a slight lull in the wind and shortly afterwards a reversal of direction, with very high velocities for the greater part of the night, but not nearly so high as during the afternoon.

A large electric power station and concrete stack located directly across the street from the New Orleans tank were destroyed and the Government Yard roundhouse, a frame structure about 200 ft. distant from the tank, was partly demolished. This tank was full of water throughout the duration of the storm and was not damaged in the least.

The La Branch tank is located 20 miles north of New Orleans in an exposed position near the shore of Lake Ponchartrain and situated in the midst of 12 or 15 houses, including the store and pumping plant of a drainage company. The tank and pump house are the only structures left standing. This tank was full of water when the storm began but water connections to houses, which were destroyed during the storm, were broken, letting the water out of the tank through openings aggregating perhaps a two inch stream. In addition to the wind at this point the level of Lake Ponchartrain was raised about 12 ft. throwing about 7 ft. of water over the top of the rail, washing away both tracks. There was no damage done to this tank and but little to the pumping station.

The Hammond tank is 54 miles north of New Orleans, and while not directly in the path of the storm, perhaps endured the most severe test of the three, as this tank was unroofed during the early part of the night of the 29th and the valve to the tank spout pulled out, allowing the tank to empty through a ten inch opening. Not more than 30 or 40 minutes were consumed in the water running out of the tank. As a result the tank undoubtedly stood a great wind pressure while empty. This strain was especially severe on account of the height of the tower. Aside from the loss of the roof this tank suffered no other damage.

SUBJECT No. 4.

SMALL COALING STATIONS.

(For the Economical Handling of 25 to 50 Tons Per Day.)

REPORT OF COMMITTEE.

There are four types of coaling stations of this class, a platform where the material is unloaded and delivered to the engines by hand shoveling; a stiff leg derrick with the necessary coal storage and operating platforms; a station where cars are pushed up an incline trestle and the coal unloaded into small pockets and delivered to the engines by gravity; and mechanical coaling stations where the coal is dropped by gravity into hoppers and elevated into large pockets by means of buckets or conveyors operated by mechanical power.

The coal platform can hardly be called a coaling station, as it is only a makeshift.

The stiff leg derrick is probably the one most used at stations where a small amount of coal is handled. The construction of the derrick at this plant is much the same as for any stiff leg derrick. The boom, however, is generally rigid, being placed at a fixed angle and far enough out to properly reach the center of the track. It is, therefore, necessary to operate only the main hoist and the swing of the derrick. Adjoining such a derrick is a storage platform of proper size and length to store as much coal as is considered necessary at the plant. At one of these stations where the average amount of coal handled per day was 12 tons, the cost of handling per ton was 17.9 cents. This station was operated by one man, assisted by the train brakemen in coaling engines. At another such coaling station, where the average amount handled per day was 31.2 tons, the cost of handling per ton was 12.6 cents. Comparatively speaking, the first cost and maintenance of a derrick station is low; the third mentioned type of station is cheaper to operate than the derrick type, although for small amounts the derrick will compare favorably with it. It costs more than the derrick, and the maintenance is much more. For small amounts the derrick is better than the trestle type of chute, and for large amounts the mechanical type is the better.

The mechanical type of station is coming into use more and more and has many things to commend it for economy of operation. It is not the intent here to discuss the merits of the different types of mechanical coal chutes, but rather whether the mechanical chute is adaptable to small stations. At a certain coaling station where an average of 44.5 tons of coal is used the cost of handling is 8.2 cents per ton. One man is employed days and one man nights. If it were necessary this amount of coal could be increased 50 per cent without increasing the number of men employed. The mechanical plant is high in first cost, and the maintenance may be considered after the plant gets old. Nevertheless, a good mechanical plant is cheap to operate and has many points in its favor even where a small amount of coal is used.

In general the cost of handling coal at small coaling stations is large, as a certain amount of labor is necessary, no matter how small the amount of coal handled. It seems advisable where small coaling stations are necessary that some other occupation should be found for the men employed in the coaling plant. Where conditions are right a water station can be operated advantageously in connection with the coaling station. If the two facilities are properly located with respect to each other and the most improved machinery is installed at both plants, one man working days and one man nights can operate the combined plant where the coal consumption amounts to about one car load per day and the water consumption amounts to about 40,000 gal. per day.

L. Jutton, (Chairman),
W. T. Krausch,
B. F. Pickering,
J. L. Talbott,
A. W. Pauba,
G. A. Manthey,
Wm. Mahan,
Committee.

DISCUSSION.

(Subject No. 4, Small Coaling Stations.)

The President:—The chairman of this committee has evidently had some difficulty in differentiating between large and small plants. It is difficult to keep down to the 50-ton limit stipulated in the paper. I think we should confine the discussion as much as possible to the small stations.

G. W. Rear:—One thing to be taken into consideration in most coaling plants is the fact that while the average consumption may be less than 50 tons, at some periods following a wreck or a congestion of freight traffic a station may be called on to supply a very large amount of coal for a short time.

R. H. Reid:—I did not understand whether or not the chairman of the committee gave the figures of the cost of elevating coal with an air hoist in small plants as applying where the air is furnished by the locomotive taking the coal, by coupling a hose to the air system on the locomotive, hoisting the buckets in that way, the only manual work required being that of filling the buckets.

L. Jutton:—The figure I gave for what I called the derrick type contemplates the use of an air cylinder. The air hoist is used only when taking coal and the figures I gave were only for the men at the coaling station. On most roads I believe the brakeman connects up the air hoist with the engine and he generally gets some time for it, probably an hour. That cost was not included in the figures given.

R. H. Reid:—What was the cost per ton on that?

L. Jutton:—There were two stations that I had figures on; one was 17.9 ct. and the other was 12.6 ct.

J. S. Robinson:—We had a small coaling station of the elevated trestle type of about 50 tons capacity in the vicinity of Chicago that was used for the coaling of switch engines, where coal was handled for about 5½ ct. per ton. We operated a small water station in connection with the coaling station and found that this cost about 5½ ct. per 1,000 gal. for the pumping. We considered that a very economical plan and we increased the plant afterwards.

The President:—I would suggest that this subject be studied more fully and be continued next year. We were not able to secure a report in advance on this subject. The committee will be continued.

Subject No 5.

COST OF STRUCTURES.

REPORT OF COMMITTEE.

In outlining the work for this committee, the Committee on Subjects specified the information to be asked for as follows:

A. Details to be kept in time book.
B. Report of materials used.
C. Records to be kept in division offices.
D. Records to be kept in general offices.
E. Analysis of costs.
F. The value and use of unit costs.
G. Gathering cost data for valuation purposes.
H. Blank Forms.

As all railroads are required by the Interstate Commerce Commission to make nearly a uniform system of reports covering construction and maintenance costs it was not considered necessary to make any recommendations along these lines but rather to confine the work of the committee to the methods of recording costs of specific pieces of work or unit costs. It was further understood that no attempt would be made to collect any actual costs as the figures from one section of the country are of no value in another unless local conditions are identical. Further, cost figures, if obtained, may be misleading and may be used for other purposes than first intended.

A circular asking for the necessary information was sent to one representative on each of 125 railroads. The parties addressed were not necessarily members of our association, but the circular was sent to the official on each road who would be most likely to have the information desired. A few questions were asked under each of the subject heads.

The replies were, in most cases, very complete and showed an unusual amount of interest in the subject. From these replies it is very evident that each railroad has a system of accounts made up to serve its own needs and in most cases the result of slow growth. Apparently there is no uniformity on the various roads either in the systems in vogue or in the results obtained and while a uniform system would seem desirable, local conditions and local requirements dictate in a large measure the details to be followed.

The adoption of any uniform system would require such a complete rearrangement of accounting methods as to be entirely outside the scope of this committee. The committee has therefore attempted to give under each question only an outline of the methods followed and in some cases to recommend a system which seems to be most desirable.

Where the term foreman is used it refers to the man having actual charge of a gang of men on some specified work regardless of what his title may be. The title supervisor as used refers to the official having general supervision of work over a considerable territory and having charge of several gangs. He may be known on different roads as supervisor, superintendent of bridges and buildings, engineer, master carpenter or one of several other similar titles.

Details to Be Kept in Time Book.

The usual practice seems to be for the gang foreman to enter in a time book for each day the time allowed for each man, with overtime and sufficient information to enable a distribution and the prescribed reports to be prepared. Very few roads require any more detail than the title of the job and possibly a few subdivisions. The majority of the roads in the country use monthly or semi-monthly time books except in a few states where weekly payments are required by law, necessitating the use of weekly time books. These time books vary from the small stock book which can be bought in stationery stores to a monthly diary giving a complete record of labor and material, an outline of the work done, a tool report and other general information required from the foreman.

It would seem desirable that a time book should be adopted of a size readily carried in the pocket and properly ruled to show one month's or one week's time as conditions may require. On a large road it would not seem desirable, however, to combine all of the foreman's monthly reports in one book, as such a book would be very cumbersome both for the foreman and for the clerks who handle the accounts.

The committee recommends a time book using one double page for the time and distribution for each man. The last page of this book should give a recapitulation, distributing the total time of the gang between the different Interstate Commerce Commission accounts, as this greatly facilitates the work of the time clerks in consolidating the distribution. A system of sub-accounts for similar work should be made up to suit local conditions and the structures on which the work is performed, such as excavation, foundation, concrete and masonry above foundation, concrete forms, steel work, framing, painting, plumbing, lighting, etc.

Reports of Materials Used.

The usual practice on most roads is for the foreman in charge of a gang to make some form of monthly material report either in a monthly diary or on loose sheets. As stated above the diary is objectionable on the larger roads as it is cumbersome. The committee considers that a material report should be sent in by itself either in a special book or on loose sheets, the reports from the different foremen being consolidated in the division supervisor's office into one material report. If a printed book is furnished to the foreman it should have pages for material received, used, and shipped and a record of the cars received.

All material shipped out on the road either from the general storekeeper or from outside parties should be billed and taken into the supervisor's stock account. He should account for it either to the storekeeper or auditor, making a monthly statement on the first of the month of the material on hand, used or shipped away, and received during the month and showing the balance on hand for each item or class of material. Large items of material used in quantities should be shown by items while smaller units, such as nails, screws, hardware, paints, etc., can be shown by classes.

Material should be distributed to various subdivisions for each job the same as labor and on its completion a completion report should be made. This should show in addition to the title of the job and the date of completion, the number of units and the cost of each class of work, such as the number of yards of excavation, the cubic yards of concrete, the number of feet of framing, the weight of steel erected, etc. It will of course be necessary to have several different forms of completion reports to cover the costs of different classes of work, such as steel bridge work, masonry, buildings, etc.

Records to Be Kept in Division Offices.

On most of the larger roads it is the custom to keep all detail records in the division offices, collecting the information from the various gangs and sub-sections, and making a complete cost record to the general offices. This is very necessary as a more accurate check can be kept on the work by so doing, the division supervisor being more closely in touch with the men.

The systems in use are very varied, including blank forms, stock ruled books and in a few cases loose leaf or card files. In many cases, so far as the keeping of unit costs or the costs of jobs is concerned, the system is left to be worked out by the individual supervisors so that there is very little uniformity even on different divisions of the same road.

Cost records which are being kept at the present time, in most cases, simply cover the accounts required by the Interstate Commerce Commission and the total cost of structures or pieces of work. It would seem very desirable that more extensive records be compiled not only to show the costs of all structures but the costs of various items going to make up the total, such as the number of cubic yards and the cost per yard for excavation, masonry and concrete work of various classes; the cost per thousand feet for framing and erecting all of the usual classes of timber work, the cost per square for roofing, flooring, siding, painting, and plastering, the cost per fixture for plumbing, the cost per square foot of radiation for steam and hot water heating and the cost per outlet or per light for gas and electric lighting installations. This is done on a few roads only and then in a very limited way. For keeping such records a loose leaf ledger or card system would seem to give the best results. It gives greater flexibility and opportunity for growth and also an opportunity for classifying similar kinds of work.

The complete cost of a piece of work should include in all cases, not only the labor and material used but the system should be such that all other items of expense such as work trains, teaming, the boarding of men and other necessary expenses should be included. The cost statement should also show any second hand material used as well as an explanation of any unusual charge due to bad weather, accidents, time lost in traveling or other items which affect the cost.

A completion report blank to cover all of this information would be so large and complicated as to be out of the question. It would therefore be necessary to make up a number of printed forms for the various classes of work. A set of forms of this kind has been made up and is made a part of this report.

Records to Be Kept in the General Offices.

With all of the detail records kept in the division offices the only cost records to be sent forward to the general offices should be cost cards or sheets showing completed structures, cards showing unit costs, and graphic tabulations or comparative statements. These records should be submitted in a form enabling the cost of similar work on various divisions to be compared and filed with as little labor as possible. By using cards or blanks of a uniform size these can be filed very readily in a card index system and a comparison made readily.

The costs of similar work on the various divisions should be tabulated to show which divisions are doing work most efficiently. Various reports showing the distribution of labor and material to maintenance of way accounts must be made to the auditing department to comply with the Interstate Commerce Commission regulations and the committee does not consider that it is within its scope to make recommendations.

Analysis of Cost.

On many of the roads complete records are kept for large construction jobs, particularly on concrete construction, the cost being analyzed and unit cost data worked out. This scheme, however, does not seem to be followed very extensively on maintenance work. Cost records on all jobs should be so kept that statements can be made up showing the distribution to the different trades, and also by unit costs as outlined under the previous subject.

It is very desirable that graphic tabulations and curves be made up to show both labor and material and total charges to all of the maintenance accounts to compare with former years. Similar graphic tabulations and curves can be made up where a number of similar structures are built on different divisions or under somewhat similar conditions but we have found only a few instances where this had been done.

Value and Use of Unit Costs.

Very few suggestions were received from the different roads under this heading. What few replies were received indicated that the system in use was satisfactory and few improvements were suggested. Some few stated that the cost records were used for a comparison of the total costs of jobs and also for valuation work and as a basis for future estimates. A system of cost records analyzed for unit costs would be of immense value to any road, not only for future estimates but especially in connection with the Federal valuation of railroads. The committee recommends that costs of this kind be kept by each railroad, feeling that the expense involved will be more than offset by the benefits to be derived from their use after a few years.

Gathering Cost Data for Valuation Purposes.

As only a comparatively few of the roads from which replies were received are under valuation, very little information was given on this subject, the work not having progressed to the stage where they can state just how the cost records are to be prepared or used. The Interstate Commerce Commission representatives have asked a few of the roads to submit cost data on standard structures and until a definite outline is prescribed for submitting this cost data we do not think the committee should commit itself. This phase of the question might be made the subject of a special report for another year.

Blank Forms.

In the circular letter which was sent out we asked for sample blanks in use to be sent in and a great many blanks were received. Most of these, however, were regular report blanks covering Interstate Commerce Commission distribution and had no relation to the subject of unit costs and are, therefore, omitted. Such blanks as directly relate to the subject are reproduced with the idea that they may prove useful in outlining a system of cost keeping.

No blanks were submitted covering graphic tabulations or curves. These are generally made up on tracing paper ruled to fit the particular work under consideration.

List of blank forms submitted for publication:

Time books,—
    C. M. & St. P., form No. 264.
    N. Y. O. & W., form R. D. No. 67.
    N. Y. N. H. & H., weekly time sheet.
Material used,—
    C. St. P. M. & O., form No. 718.
Completion report and cost report,—
    C. M. & St. P., No. 120, cost of buildings.
        No. 114, masonry cost data.
        No. 125, substructure cost data.
    St. L. & S. F., M. W., No. 3, cost of masonry.

Set of card forms for compiling unit costs prepared by the committee.

G. A. Rodman,
F. E. Weise,
J. H. Nuelle,
J. S. Robinson,
R. C. Sattley,
C. W. Wright,
W. A. Pettis,
Committee.

U 69

Division.. **Appro. No.**........................

Title.. **Amount**........................

Description.. **Date of Appro.**........................

.... **Completed**........................

Reported

	Excavating and Grading		Foundations		Mason Work Above Foundations		Carpenter Work		Mill Work		Plumbing Heating and Lighting		Roofing		Platforms		Painting			
Balance																				
January																				
February																				
March																				
April																				
May																				
June																				
July																				
August																				
September																				
October																				
November																				
December																				
Total																				

(Size of Sheet 5"x8")

Form C-37

BRIDGE PAINTING

BRIDGE No.

NEAREST STATION BRANCH DIVISION

DATE STARTED DATE COMPLETED CONDITION OF OLD PAINT

WHAT PORTION PAINTED WEIGHT OF STEEL

COST RECORD	NO. GALS. OF PAINT	COLOR OF PAINT	MAKE OF PAINT	COST PER GAL.	COST MISC. MATERIAL	TOTAL COST MATERIAL	COST PAINTER LABOR	COST STAGING & CLEANING	TOTAL COST
TOUCHED UP									
1ST COAT									
2ND COAT									
3RD COAT									

TOTAL MATERIAL

TOTAL LABOR

TOTAL

COST PER TON

(Size 5"x8")

FOREMAN .... CORRECT .... GEN. FOREMAN

ON LARGE BRIDGES USE SEPARATE CARD FOR EACH SPAN. EXPLAIN ON BACK RECORD OF WEATHER CONDITIONS AND ANY REASON FOR EXCESSIVE COST.

Form C-37-A

BUILDING PAINTING

STRUCTURE DIVISION

DATE STARTED DATE COMPLETED CONDITION OF OLD PAINT

WHAT PORTION PAINTED

COST RECORD		NO. GALS. OF PAINT	COLOR OF PAINT	MAKER OF PAINT	COST PER GAL.	COST MISC. MATERIAL	TOTAL COST OF MATERIAL	COST PAINTER LABOR	COST OF STAGING & CLEANING	TOTAL COST
OUTSIDE	BODY									
1st COAT	CANOPY									
AREA	TRIM									
OUTSIDE	BODY									
2nd COAT	CANOPY									
AREA	TRIM									
INSIDE	BODY						(Size 5"×8")			
1st COAT	CEILING									
AREA	TRIM									
INSIDE	BODY									
2nd COAT	CEILING									
AREA	TRIM									
ROOF	1ST COAT									
AREA	2ND COAT									

TOTAL MATERIAL

TOTAL LABOR

TOTAL

FOREMAN .... CORRECT .... GEN. FOREMAN

EXPLAIN ON BACK ANY REASON FOR EXCESSIVE COST AND WEATHER CONDITIONS

Form Engr 114.

Chicago, Milwaukee & St. Paul Railway Company

ENGINEERING DEPARTMENT

MASONRY COST REPORT

STRUCTURE OR BRIDGE NO.______

W. O. NO.______ **DR. NO.**______

LABOR

FOREMAN	MONTH	Concrete Masonry	Concrete Forms	Arch Centers	Moving (to Include Traveling)	Foundations	Foundation Piles	Stone Paving Dry Walls Rip Rap Back Filling Spotting	Water Proofing	Bridge Falsework	General Office	Engineering and Superintendence	Erection		TOTAL
TOTALS															
AVERAGES PER CU. YD. CONCRETE															

(Size 8½" x 14")

MATERIAL

	Sacks of Cement	Cu. Yds. of Crushed Stone	Cub. Yds. of Sand or Gravel	Ft. B. M. of Form and Arch Lumber (Net)	Lbs. of Form and Arch Hardware, Net	Ft. B. M. of Cofferdam Lumber (Net)	Lbs. of Reinforcing Metal	Lin. Ft. of Foundation Piles	Lin. Ft. of Falsework Piles	B. M. Ft. of Falsework Material	Total Cost of Miscellaneous Concrete Mat'l
TOTAL QUANTITY											
AVERAGE QUANTITY											
	PER CU. YD. CONCRETE										
ACTUAL COST											
AVER. COST PER CU. YD.	Items of Cost to be filled in by the Chicago Office										

(To be Filled in by Chicago Office)		COST PER CU. YD. CONCRETE	Above Structure	General Average For Same Class of Work For 191___	191___
Labor	"E"	Including Only First Three Labor Columns			
	"F"	Including Only First Five Labor Columns and Some Miscel. Items			
Materials	"G"	Including Only First Five Material Columns			
	"H"	Including Only First Seven Material Columns and Some Miscl. Items			
Totals		Sum of "E" and "G"			
		Sum of "F" and "H"			

GENERAL INFORMATION

LOCATION	ORIGINAL STRUCTURE	FINAL STRUCTURE

CONCRETE QUANTITIES

FOOTING		NEATWORK				TOTAL
Class	Cu. Yds.	Class	Cu. Yds.	Class	Cu. Yds.	Cu. Yds.

MISCELLANEOUS QUANTITIES

NO. FDTN. PILES	NO. FALSW. PILES	TOTAL CU. YARDS EXCAVATION	SQ. YDS. OF FORM SURFACE AND SOFFIT

Class of Concrete	Proportions of Cement, Sand and Stone	Proportions of Cement, Gravel and Stone
"AA"		
"A"		
"B"		
"C"		

EXCAVATION AND FOUNDATION WORK

% Easy	% Moderately Difficult	% Very Difficult

Concrete Mixed by Hand Machine

Work Started______191___

Work Completed______191___

REMARKS______

______ **DATED**______**191**___

______ **ASS'T ENG'R** ______ **DIST. ENG'R**

PROGRESS, or COMPLETION } **REPORT.**

.... 191

Mr. ....

DEAR SIR: ....

The following is a report of Concrete work done on .... at Telegraph Pole No. ...., near .... Division, during the week ending .... This work was started ...., 191 The foundation is .... feet deep below base of rail and consists of ....

DATE	WEATHER	FOREMAN	Brand of Cement	Kind of Concrete (Chats, Stone, Etc.)	Proportions used for:		Cu. Yds. Laid Each Day	Total Cu. Yds. Laid to Date	Total Cu. Yds. in Completed Structure		REMARKS
					Purpose	Proportions					
SUN.											
MON.											
TUES.											
WED.											
THURS.											
FRI.											
SAT.											
TOTAL											

REMARKS: ....

(Size 8½" x 11")

The details of the total cost of all the concrete work on this structure is to be filled in below on the Completion Report, which is the last of above reports.

ITEM	QUANTITY USED	TOTAL CUBIC YARDS AND COST, IN:														
		Foundation			Superstructure Excluding Arches or Bridge Seats			Arches			Bridge Seats			TOTAL STRUCTURE		
		Yards	Total Cost	Cost per Cu. Yd.	Yards	Total Cost	Cost per Cu. Yd.	Yards	Total Cost	Cost per Cu. Yd.	Yards	Total Cost	Cost per Cu. Yd.	Yards	Total Cost	Cost per Cu. Yd.
Material																
Forms	ft. B. M.															
Iron and Steel	lbs.															
Cement	lbs.															
Sand	cu. yds.															
Chats	cu. yds.															
Broken Stone	cu. yds.															
Slag	cu. yds.															
Gravel	cu. yds.															
Water	gals.															
Labor																
Excava'n	hrs. @															
Forms	hrs. @															
Mixing Concrete	hrs. @															
Placing Concrete	hrs. @															
Removing Forms	hrs. @															
Tools																
Inspection Work Tr'n Service																
TOTAL COST																

Report Blank for Concrete Work, St. Louis & San Francisco R. R.

DAILY RECORD OF TIME

Name____

Description and Location of Work.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(Size 6½"x9½")															
Hours worked each day.															

Days Worked First Half____________ **Rate**________ **Amount**________

Time Book, New York, Ontario & Western R. R.

Month of____________________**191**____

Occupation__________________________ **Rate**__________

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Hours.	Total Amount.		Distribution.

Days Worked Last Half____________ **Rate**_______ **Amount**_______

Time Book, New York, Ontario & Western R. R.

Name

.... No. ....

OCCUPATION..

A. F. E. OR WORK ORDER	LOCATION STATION OR BRIDGE NUMBER	DESCRIPTION OF WORK DONE
		(Full Size)

C. M. & St. P. Time Book, Engineering Department.

Time for..................half of Month of..............................19............

Rate per..............................$..............................

DATE	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL TIME	AMOUNT	
		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		$	Cts.
ACTUAL HOURS WORKED																			
TIME ALLOWED FOR OVERTIME																			
TOTAL TIME																			

C. M. & St. P. Time Book, Engineering Department.

9-4-13—2M. Engn. 128.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

ENGINEERING DEPARTMENT.

Statement of cost of a .... *built at* .... *Station,*

as per Drawing No. .... *Work completed during month of* .... *191*....

GENERAL DESCRIPTION

Size .... *Height* .... *Length* .... *Depth* ....

MATERIAL	QUANTITIES USED	TOTAL COST	LABOR	TOTAL COST
Lumber and Timber	*ft. bm.*		*Carpenters*	
Piles	*lin. ft.*		*Pile Driver*	
Iron, including nails	*lbs.*		*Iron Workers*	
Rubble stone	*cu. yds.*		*Stone masons and tenders*	
Crushed stone	*cu. yds.*		*Concrete*	
Brick	*M.*		*Brick laying*	
Cement—Portland	*bbls.*		*Common Labor*	
" *—Natural*	*bbls.*		*Other Labor*	
Sand	*cu. yds.*			
Pipe and fittings—Size	*lin. ft.*			
Mill work			(Size 8½" x 14")	
Machinery				
Other Material				
Cost of Material			*Total Cost of Labor*	

Estimated cost, $ .... *Cost of structure, complete, $* ....

ANALYSIS OF COST—(Including labor and material).

.... *Cu. Yds. Rubble Masonry, cost per cu. yd* ....

.... " " *Brick* " " " " ....

.... " " *Concrete* " " " " ....

.... " " *Excavation,* " " " ....

Pile driving—Per lin. ft. piles .... *Pipe laying, per lin. ft.* ....

Paving .... *Per sq. yd.* .... *Stock yards, per sq. ft. floor* ....

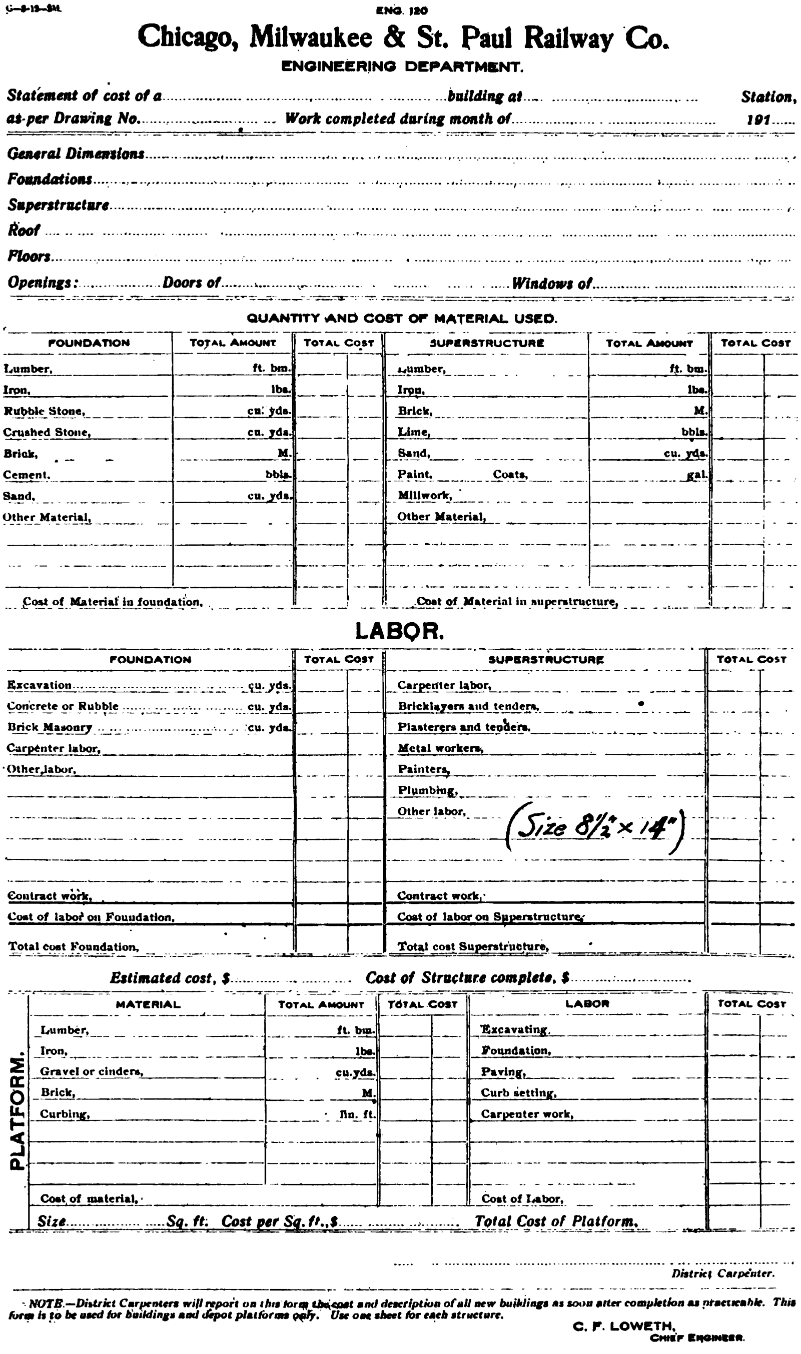
REMARKS: ....

District Carpenter.

NOTE.—This form is to be used in reporting cost of all new work and miscellaneous structures (except Bridges, Buildings and Platforms), including Turntables, Scales, Windmills and Towers, Watertanks, Stockyards, Pumping Plants, Pits of all kinds, Water pipes, Stand pipes, Wells, Sewers, Masonry, Trestles, Paving, etc., etc.

Use a separate sheet for each job or structure.

C. F. LOWETH,
CHIEF ENGINEER



C—8-13—5M. ENG. 120

Chicago, Milwaukee & St. Paul Railway Co.

ENGINEERING DEPARTMENT.

Statement of cost of a .... *building at* .... *Station,*
as per Drawing No. .... *Work completed during month of* .... *191*......

General Dimensions ....
Foundations ....
Superstructure ....
Roof ....
Floors ....
Openings: .... *Doors of* .... *Windows of* ....

QUANTITY AND COST OF MATERIAL USED.

FOUNDATION	TOTAL AMOUNT	TOTAL COST		SUPERSTRUCTURE	TOTAL AMOUNT	TOTAL COST	
Lumber,	ft. bm.			Lumber,	ft. bm.		
Iron,	lbs.			Iron,	lbs.		
Rubble Stone,	cu. yds.			Brick,	M.		
Crushed Stone,	cu. yds.			Lime,	bbls.		
Brick,	M.			Sand,	cu. yds.		
Cement,	bbls.			Paint, Coats,	gal.		
Sand,	cu. yds.			Millwork,			
Other Material,				Other Material,			
Cost of Material in foundation,				Cost of Material in superstructure,			

LABOR.

FOUNDATION	TOTAL COST		SUPERSTRUCTURE	TOTAL COST	
Excavation .... cu. yds.			Carpenter labor,		
Concrete or Rubble .... cu. yds.			Bricklayers and tenders,		
Brick Masonry .... cu. yds.			Plasterers and tenders,		
Carpenter labor,			Metal workers,		
Other labor,			Painters,		
			Plumbing,		
			Other labor, (Size 8½" × 14")		
Contract work,			Contract work,		
Cost of labor on Foundation,			Cost of labor on Superstructure,		
Total cost Foundation,			Total cost Superstructure,		

Estimated cost, $ .... *Cost of Structure complete, $* ....

PLATFORM.

MATERIAL	TOTAL AMOUNT	TOTAL COST		LABOR	TOTAL COST	
Lumber,	ft. bm.			Excavating,		
Iron,	lbs.			Foundation,		
Gravel or cinders,	cu. yds.			Paving,		
Brick,	M.			Curb setting,		
Curbing,	lin. ft.			Carpenter work,		
Cost of material,				Cost of Labor,		

Size .... *Sq. ft. Cost per Sq. ft., $* .... *Total Cost of Platform,*

....
District Carpenter.

NOTE.—District Carpenters will report on this form the cost and description of all new buildings as soon after completion as practicable. This form is to be used for buildings and depot platforms only. Use one sheet for each structure.

C. F. LOWETH,
CHIEF ENGINEER.

ENGR. 328 DATE

C. M. & ST. P. RY. CO.——ENGINEERING DEP'T.—— TIME CHECKING SHEET.

Job Number

SERIES 100

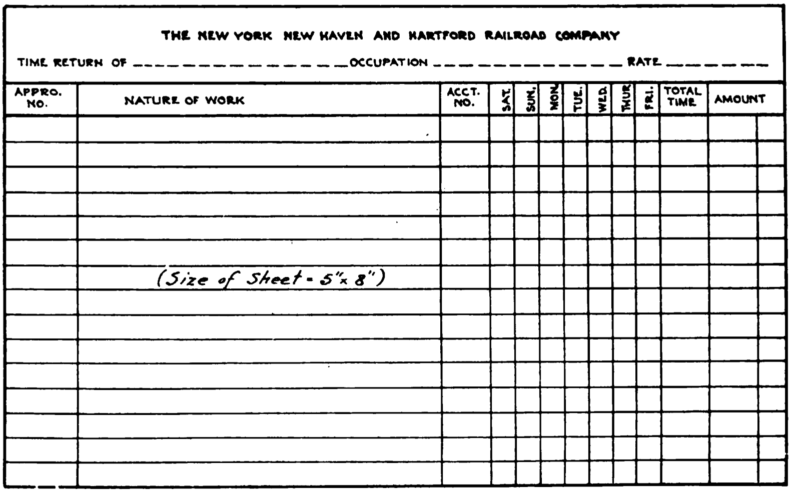
No.	CHECKER				Building forms - Addison St.	Excavating Ret. Wall - Clark St.	Placing Concrete Abut.-Monroe St.										HOURS
					1	2	3										
0	2	2	2	2		10											10
1																	
2																	
3	1	1	3	3	5		5										10
4																	
5																	
6	2	3	3	3		3	7										10

Size, 8" (Vert) x 13" (Hor.)

Numbers run from 0 to 99

SERIES 100

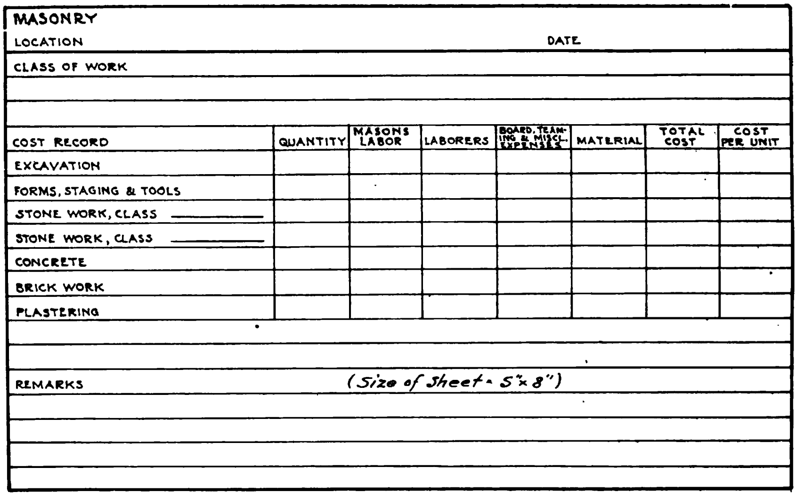
No.	CHECKER																HOURS
50																	
51																	
52																	
53																	
54																	
55																	
56																	



THE NEW YORK NEW HAVEN AND HARTFORD RAILROAD COMPANY

TIME RETURN OF ______________ OCCUPATION ______________ RATE ________

APPRO. NO.	NATURE OF WORK	ACCT. NO.	SAT.	SUN.	MON.	TUE.	WED.	THUR.	FRI.	TOTAL TIME	AMOUNT	
	(Size of Sheet - 5"x 8")											



MASONRY

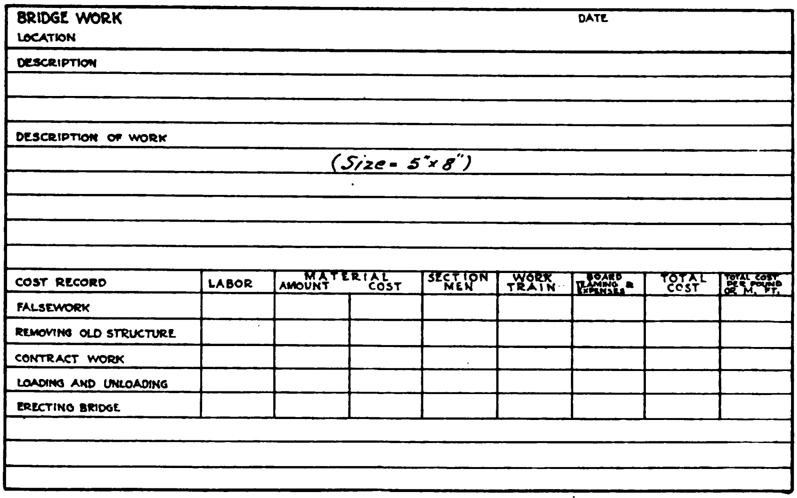
LOCATION DATE

CLASS OF WORK

COST RECORD	QUANTITY	MASONS LABOR	LABORERS	BOARD, TEAMING & MISCL. EXPENSES	MATERIAL	TOTAL COST	COST PER UNIT
EXCAVATION							
FORMS, STAGING & TOOLS							
STONE WORK, CLASS ________							
STONE WORK, CLASS ________							
CONCRETE							
BRICK WORK							
PLASTERING							

REMARKS (Size of Sheet - 5"x 8")

Blank Forms Prepared by the Committee.



BRIDGE WORK DATE

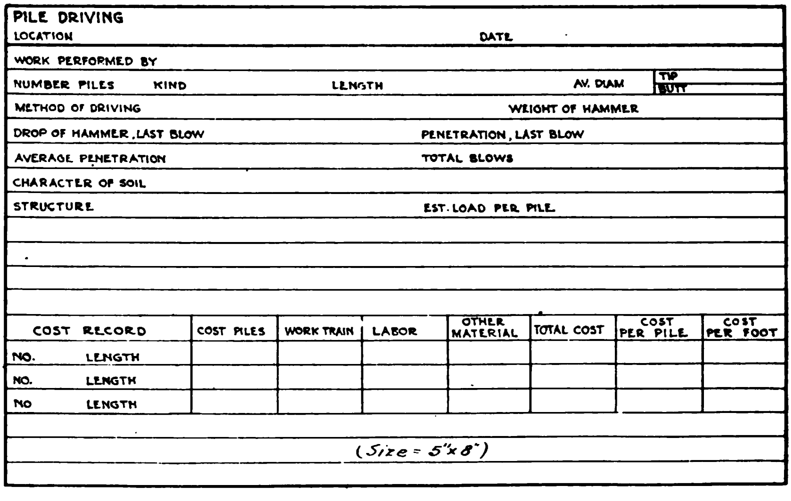
LOCATION

DESCRIPTION

DESCRIPTION OF WORK

(Size = 5"x 8")

COST RECORD	LABOR	MATERIAL		SECTION MEN	WORK TRAIN	BOARD TEAMING & EXPENSES	TOTAL COST	TOTAL COST PER POUND OR M. FT.
		AMOUNT	COST					
FALSEWORK								
REMOVING OLD STRUCTURE								
CONTRACT WORK								
LOADING AND UNLOADING								
ERECTING BRIDGE								



PILE DRIVING

LOCATION DATE

WORK PERFORMED BY

NUMBER PILES KIND LENGTH AV. DIAM TIP BUTT

METHOD OF DRIVING WEIGHT OF HAMMER

DROP OF HAMMER, LAST BLOW PENETRATION, LAST BLOW

AVERAGE PENETRATION TOTAL BLOWS

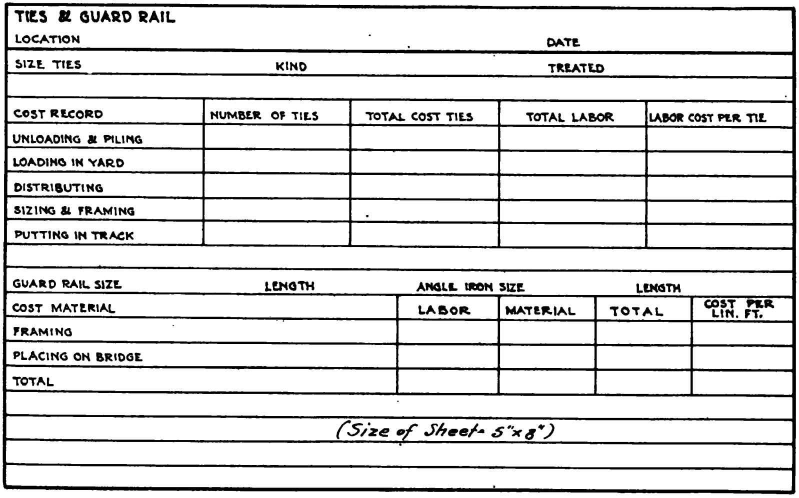
CHARACTER OF SOIL

STRUCTURE EST. LOAD PER PILE

COST RECORD	COST PILES	WORK TRAIN	LABOR	OTHER MATERIAL	TOTAL COST	COST PER PILE	COST PER FOOT
NO. LENGTH							
NO. LENGTH							
NO LENGTH							

(Size = 5"x 8")

Blank Forms Prepared by the Committee.



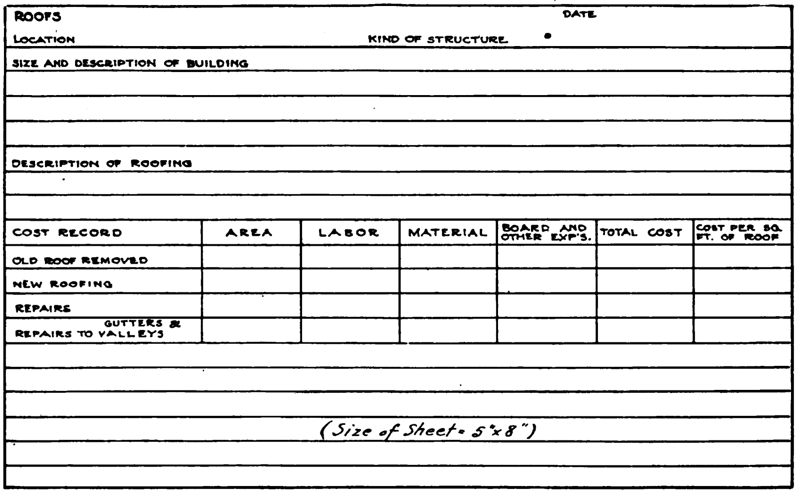
TIES & GUARD RAIL
LOCATION DATE
SIZE TIES KIND TREATED

COST RECORD	NUMBER OF TIES	TOTAL COST TIES	TOTAL LABOR	LABOR COST PER TIE
UNLOADING & PILING				
LOADING IN YARD				
DISTRIBUTING				
SIZING & FRAMING				
PUTTING IN TRACK				

GUARD RAIL SIZE LENGTH ANGLE IRON SIZE LENGTH

COST MATERIAL	LABOR	MATERIAL	TOTAL	COST PER LIN. FT.
FRAMING				
PLACING ON BRIDGE				
TOTAL				

(Size of Sheet- 5"x8")

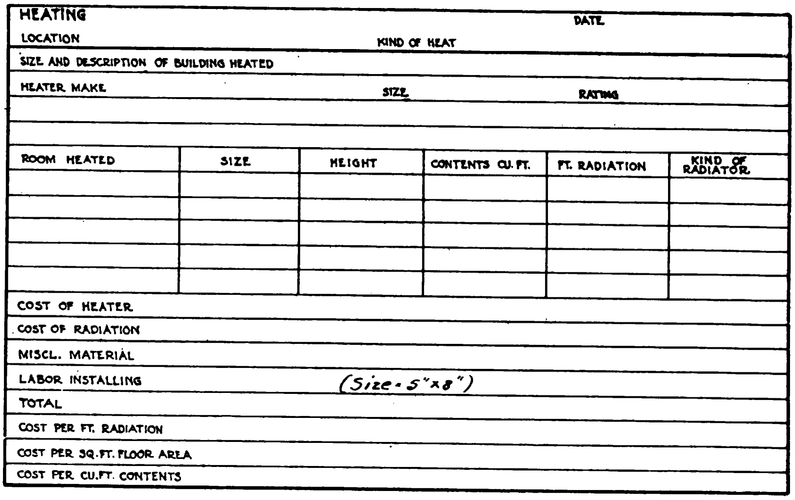


ROOFS DATE
LOCATION KIND OF STRUCTURE
SIZE AND DESCRIPTION OF BUILDING
DESCRIPTION OF ROOFING

COST RECORD	AREA	LABOR	MATERIAL	BOARD AND OTHER EXP'S.	TOTAL COST	COST PER SQ. FT. OF ROOF
OLD ROOF REMOVED						
NEW ROOFING						
REPAIRS						
GUTTERS & REPAIRS TO VALLEYS						

(Size of Sheet- 5"x8")

Blank Forms Prepared by the Committee.



HEATING DATE

LOCATION KIND OF HEAT

SIZE AND DESCRIPTION OF BUILDING HEATED

HEATER MAKE SIZE RATING

ROOM HEATED	SIZE	HEIGHT	CONTENTS CU. FT.	FT. RADIATION	KIND OF RADIATOR

COST OF HEATER

COST OF RADIATION

MISCL. MATERIAL

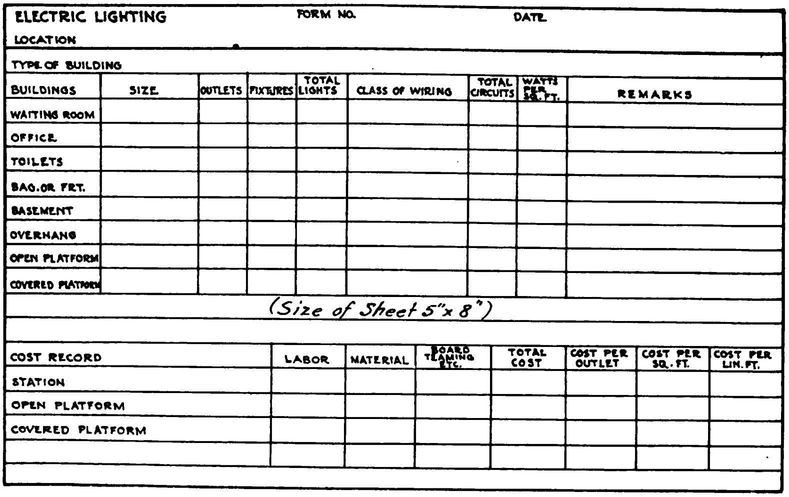
LABOR INSTALLING (Size - 5"x8")

TOTAL

COST PER FT. RADIATION

COST PER SQ. FT. FLOOR AREA

COST PER CU. FT. CONTENTS



ELECTRIC LIGHTING FORM NO. DATE

LOCATION

TYPE OF BUILDING

BUILDINGS	SIZE	OUTLETS	FIXTURES	TOTAL LIGHTS	CLASS OF WIRING	TOTAL CIRCUITS	WATTS PER SQ. FT.	REMARKS
WAITING ROOM								
OFFICE								
TOILETS								
BAG. OR FRT.								
BASEMENT								
OVERHANG								
OPEN PLATFORM								
COVERED PLATFORM								

(Size of Sheet 5"x 8")

COST RECORD	LABOR	MATERIAL	BOARD TEAMING ETC.	TOTAL COST	COST PER OUTLET	COST PER SQ. FT.	COST PER LIN. FT.
STATION							
OPEN PLATFORM							
COVERED PLATFORM							

Blank Forms Prepared by the Committee.

DISCUSSION.

(Subject No. 5. Costs of Structures.)

R. C. Sattley:—One order of the Interstate Commerce Commission has given me a great deal of satisfaction. We are now absolutely required to give the cost of each individual structure. The accounting department of every railroad must keep in detail all the elements of quantity and price entering into that cost and they have taken away a great deal of our burden. At one time I was connected with a railroad and with a local association of B. and B. superintendents employed by that road. At the first meeting we held, the severest criticism I received was on account of the thoroughness with which I was keeping my cost—I was wasting too much of the company's money to make bookkeepers out of foremen. It is a great satisfaction to me to know that I now have the Interstate Commerce Commission with me and that everybody now has to come in line.

J. N. Penwell:—Mr. Sattley has touched on a point I wanted to speak about. When our road was considered an insignificant line by some of the larger New York Central lines and I wanted to adopt the Lake Shore method of accounting in my office, I had at that time only three clerks in the office, and the chief engineer's clerk asked me if I realized what it would cost. I said that it would cost $125 a month additional to put it into effect. He said, " Is it worth it? " I said it would be. He said, " The L. E. & W. cannot afford it." I said, " Perhaps it cannot, but I think it is worth it; later on you will ask me just what the Lake Shore officials are asking their men and I will not be prepared to give it." We drifted on and I put on the clerks one by one until I now have six and I lack two yet to keep the accounts as they really should be kept. Of course that is a mistake of the past, as we all realize, and I fully endorse Mr. Sattley's view that we should keep more thorough accounts of our work. If I had put those two clerks on 11 years ago, I would now be prepared to furnish just such data as Mr. Sattley has to furnish to the Interstate Commerce Commission. The valuation work has not reached us yet to such a degree as the Rock Island, but it is coming later.

While we do not, as a rule, make forms, I think every bridge and building man should study that subject. Our chief engineers have consulted me about forms and I have helped prepare a number which have been adopted and are in use on our railroad. There are two classes of forms in accounting; those required by the government and those needed for our own use. The man in the field is in a good position to help work out those forms. Two or three of the forms worked out in my office are still in use. I mention this simply that we may acquaint ourselves with what is going to be required of us and not be afraid to make suggestions. Our officers are ready for suggestions if the suggestions carry any weight. If the suggestions are chaffy they have no use for them, of course, but if the ideas are of real value, they will listen to you as attentively on the subject of making up forms to shorten your work and give a better record of it, as on any other subject.

R. C. Sattley:—I want to say for the information of Mr. Penwell and others, that the Interstate Commerce Commission's orders went into effect June 30, 1915. Every railroad has to keep its accounts so that the government accountants can step into its office at any time and get from the records every unit of quantity and of price entering into the cost of every individual structure. One cannot have an A. F. E. order made up to cover a dozen bridges and distribute the money between them but he has to have a separate order for every piece of work. The accounting department is required to keep it that way, and every accounting officer has issued instructions that every cost of that kind shall be kept, so that we are getting satisfaction at last.

G. W. Rear:—We who have anything at all to do with this line of work all know that the original bookkeeper on the railroad is the foreman, no matter whether he is a section or a bridge and building foreman. The best basis to enable the foreman to give the proper accounting is to have a proper estimate made in the first place when application is made for the A. F. E. When this application is made it should be estimated on the lines on which it is desired that the cost statement be made. On our railroad, the application for authority is made up with a certain style of estimate and the foreman must follow the lines of the original estimate in all his reports. That estimate gives the foreman an idea of what he is supposed to do, and at the same time it gives every other man down to the auditor proper information so that this account can be made up. Mr. Sattley neglected to state that in this requirement of the Interstate Commerce Commission some certain person on each railroad must be prepared to swear to all of these cost statements.

R. C. Sattley:—The valuation engineer has to swear to everything on his road.

G. W. Rear:—And everybody else swears at him.

C. R. Knowles:—As I understand it the manner of making up the work authority is covered by valuation order No. 3, which specifies just how it must be prepared. We have no choice in that matter but we have to comply with the order.

E. T. Howson:—I believe that if the average contractor handled his work in reference to his knowledge of costs as loosely as the average railroad does, he would disappear very shortly from the contracting field. The vital factor for the contractor to know is what his work is costing him. He knows what he is going to receive for his work and he must keep his costs below that figure. To the average railroad construction organization unit costs are secondary. The foreman on the work and the supervisor know only in a very general way, if at all, what the work is costing. Under these conditions there is no incentive to reduce the cost. The money factor is not emphasized as it should be. One railroad has recently added the cost of each item in its material books furnished to its foremen. For instance when a foreman orders 10 shovels he puts down 10 shovels and then he puts the cost after them, thus impressing on him the fact that he is handling dollars as well as shovels.

As an instance of the way the value of material is overlooked, a road master called my attention about two weeks ago to an incident that occurred on a western railroad within the last 60 days. Owing to retrenchment he was instructed not to mow the right of way this year. He took it up with his superintendent and received tentative authority to disregard that instruction on a limited mileage. He mowed that right of way and recovered enough scrap in the way of draw bars and other material which had been thrown off the bank to more than pay the cost of the mowing, and this was on a road which is considered a well maintained road.

In making estimates of the cost of work on the average railroad, the intent is not so much to put in figures showing what the work should be done for, as to place the figures high enough so it will not be necessary to explain an excess. That again defeats the very purpose of cost data, and is one reason why much work can be done by contractors cheaper than with company forces. I went over a piece of work two or three weeks ago which had been under way two or three years with company forces. A contractor whose work had run out during the depression came over in charge of this railway work as superintendent of construction. He at once revised the methods of operation considerably and has also reduced very materially the unit cost of depositing concrete—this is a large concrete job—simply by putting into use the methods a contractor would use, and watching his cost data. He knows by 10 o'clock the following morning what it cost him per yard to put in concrete the day before. He told me they had been rushing the construction and that it had been the practice to work the men Sundays. From experience gained in contracting, he checked over the payroll and found that 75 per cent of the men who worked Sunday, receiving time and a half, lay off a day during the week; consequently, the company was paying time and a half for one day in the week and getting no more work from these men. His attention was called to this by the fact that his unit cost on Sunday ran up considerably higher than on other days during the week.

It is only by having unit costs up to the minute that a man can detect those leaks and if he cannot detect them, they will never be stopped.

J. N. Penwell:—Mr. Howson has sounded the keynote. I presume every man in the house would like to furnish his report in just that concise manner. One of our old chief engineers said to me one day, " John, I want to know tomorrow morning, what your work cost today." I said, " So do I, but I lack 100 per cent of having office force enough to handle it in that way." The contractor puts on the man he needs. When he finds that it is an advantage to that work to put on another clerk or an assistant foreman to look after the details he puts him on, but we have to get the permission from some higher officer, perhaps the president. Our accounts are deplorably lacking because we cannot put on the men we need.

The President:—All this discussion goes to show that we are considering a vital topic. It seems to me that this prescribing of definite forms for costs is going to help us out individually as much as anything. We are going to be compelled to furnish data. That will mean that our superior officers will be compelled to furnish us with the clerical help necessary to furnish this data. One point was brought out by Mr. Howson's remarks on which I would like to add just a word. Contractors generally are coming more and more to use a better class of men for their time keepers. Hitherto railroad policies have not permitted that, but I think we are going to see the day now where we are going to be provided with clerical help on all work more adequate to our needs. Another point: formerly a bridge and building man was not necessarily supposed to keep very much tab on his cost accounting. He has to do that now which means that he must know all about the methods prescribed. It is along the line of change which we are experiencing in all lines of work. We have to adapt ourselves to the rapidly changing conditions.

SUBJECT NO. 6.

EFFICIENCY.

By Geo. W. Rear.

The word Efficiency has been given great prominence during the past few years, and the general public has been led to believe that the lack of efficiency has been the cause of all railroad troubles, and also that this new discovery was the remedy for our financial ills. During the hearings on rate increases before the Interstate Commerce Commissions, extravagant claims were made not only in regard to the inefficiency of present methods, but also regarding what could be saved through " Efficiency." Volumes have been written on the subject and much discussion, more or less bitter, has resulted, so this subject is a timely one for our discussion.

In taking up the subject of " Efficient Methods of Handling Work and Men," the committee decided to go into it from the view-point of the practical man, and assume the word " Efficiency " to mean, **" the obtaining of the most satisfactory results."** The members of this association are, in almost every case, responsible for the results secured by the men of the Bridge and Building department in their respective territories, and it will be the endeavor to bring out as many as possible of the features that tend to cause or prevent efficiency.

The work of the Bridge and Building department is of such great variety that it covers almost every one of the building trades and some of the mechanical trades as well, and as it is scattered over a large territory it is hardly to be expected that as great efficiency can be secured as where the work is concentrated and can be given closer supervision.

We are inclined to think that there are not as good men now as there used to be years ago. From a physical standpoint this is probably true, because in the earlier days the ranks were filled with men trained in the lumber camps and shipyards and inured to the hardships of pioneer life in the settlement of this continent. Wonderful tales are told of the prowess of that race of wood workers, and enough individual instances remain to prove that their achievements were real and not due to that exaggeration which time casts over the doings of the past. These men were the survival of the fittest—the unfit being weeded out before they reached us.

Their accomplishments were due to efficiency; to that training of hand that resulted in every move counting toward the desired end. This race of men were artists with the saw, the axe and the adze. They could go into the forest and get out and frame any kind of a railroad structure without outside help, excepting for the ironwork. But at what a waste of human energy! Their work was all done by hand and they cheated horses and steam engines out of millions of days' work. Not only did they do work that ought to have been done by other power but they did a great deal of work that was a pure waste of energy, work that need not have been done at all, adding neither to the strength nor to the looks of the structure. Think of all the mortise and tenons used in framing, the dove-tail corners in cribs, etc. This was the era of the strong back and indicated efficiency in the **narrow** or **technical** sense of the mastery of work by the training of the hand.

As old age claimed these efficient men one by one, what was done to replace them? Having always been able to hire skilled tradesmen, that system was followed, and mechanics were hired who had learned their trades elsewhere and who were not accustomed to the rough, hard work of bridge construction. These men were an average lot, the weaklings not yet having been culled out, and we jumped to the conclusion that the race had deteriorated.

While the average gang had depreciated from a physical standpoint, it had appreciated from a mental standpoint, the men being better educated and capable of using their heads as well as their hands. It was the dawn of a new era, an era where the value of the head must count and not the horsepower only of the man. Up to this time a railroad job in the Bridge and Building department was about as good as any other job in the same trade and a railroad had no difficulty in getting a reasonable supply of fairly well trained men. But the great industrial expansion of this continent claimed the more ambitious workers and the railroads found good men to be scarce.

The railroad job was not attractive during good times for several reasons, the principal of which were, low wages (wages not having kept pace with those paid by other employers) and the discomfort of being away from home when engaged in railroad work. Railroads were then forced to hire untrained men and to educate them into skilled workers, with the result that they became the recruiting grounds for the contractor who desired trained help without going to the trouble of training it. Better wages and improved living conditions coaxed the men away. This was the situation up to the time the present depression began and will probably be the situation again when times get better, unless something is done to remedy it.

Before going into the conditions of labor, let us look at the personnel of the department, beginning with the men in the ranks. Has the system of hiring skilled men been satisfactory? In rare cases, yes, in the majority of cases, no.

The mature man one hires usually has some drawback; he is a wanderer or a chronic kicker, or has one or more of the many faults human nature is heir to. He often expends more energy hunting a job than he does in holding it after he secures it. He has probably made up his mind that a railroad job is a snap and he tries to make it one.

When men are scarce and work must be done, these men must be tolerated, but at a great loss of efficiency in the work. The only alternative is to keep the good men that we have and hire young men and train them ourselves. This is the foundation on which we must build the department and the solidity of the foundation depends on many things, a few of which will now be considered.

The most important question is: Why do men leave us? Assuming that we have trained a man, what do we lose when we lose his services? Perhaps the railroad does not lose much in dollars and cents, as the man probably earned all he got while being trained, but it has lost a very material part of the organization and the benefit of his service in the years to come. One reason his training has not cost much is because he probably acquired it by absorption, no especial pains have been taken to train him. He began as a laborer, worked a year or two and became a handy-man, then securing a few tools he became a mechanic.

Is he encouraged to advance? Probably not. If he is energetic, smart or likely to become a valuable man is he dropped or "hidden under a bushel" for fear he will displace some older man? Is he kept away from home for weeks at a time and considered a nuisance if he asks for transportation home often enough to keep up an acquaintance with his family or associates? Are his wages anywhere near what they ought to be? Are his living conditions good or even fair? Is he "docked" for every minute's lost time and laid off whenever work is slack? In other words, is his job worth having? These are questions that must be looked squarely in the face. They have little or nothing to do with what work a man will accomplish, but they are of vital importance as to whether or not we have any men at all.

The next or perhaps the most important question is whether a man is entirely dependent for his job on the whims and fancies of the man next above him. Is he hired and fired on the slightest pretext? Does the company know that he exists or does it care? Can he call himself a "railroad man" or is he only hanging on by the skin of his teeth? There are thousands of young men of fair education looking for a start on a life career every year. Are we getting our share of them? Have we anything to offer them? On the answers to these questions depends the future efficiency of the Bridge and Building department.

This department is efficient now, probably more so than other departments, but it is so largely in spite of conditions except where proper methods are in force. Conditions are nowhere ideal, but much has been done, mainly by individual effort. If we are to hold our own, we must go into this matter and make things what they ought to be. Therefore, if we are to get and keep good men we must hire young men of good health, good habits and fair education; put them at unskilled work, (if there is such a thing, which we doubt) and give them a chance to learn the business, for it is a trade or profession of its own.

We must pay them fair wages: What fair wages are is open to discussion, but it does not help the department to have passenger brakemen leave the farm and get more pay to begin with than bridge and building men ever hope to get. We must make their living conditions agreeable. If required to be away from home we should give them good living accommodations, and try to remember that some of these men spend half their lives in an outfit car. Don't crowd too many men in a car but provide some privacy. Arrange it so that men who are congenial can be by themselves. Don't forget to feed them; quantity and variety of provisions are not the only things to consider; the way and place that food is served have a lot to do with whether or not the men are satisfied.

Let the men go home often. The man who remains closest to civilization is the best citizen and the most valuable man. If circumstances permit, let him go home every night; don't keep him away for fear that the boarding camp will lose money or to save some clerk the trouble of writing passes. Consider transportation as a man's right and do not try to make him think that he is getting it as a favor.

Treat the man as a human being and as an equal in everything except responsibility and authority and make his job as secure as that of any other employé. He will be proud of his job and it will be easy to keep him. Do not drive too close a bargain with him and do not expect to get more than you pay for. Men should be hired with as great care as those for any other department. A fair education should be insisted upon and a physical examination given. This examination should be governed somewhat by the trade he is to follow, without blindly turning down all applicants that are not perfect, but should be strict enough to cull out all those not physically fit to do a day's work. It is too bad that the microbe of laziness can not be detected.

These employés, (and they are that) should be considered as employés of the railroad and not of a gang. They should be transferred frequently from gang to gang and given an opportunity to learn the standards of work and the methods used by different foremen in performing it. The men themselves should show a desire to become real railroad employés, to learn the business and to put up with its inconveniences without "growling."

These men will not have any trade and will work as helpers, but will soon become capable of doing some kind of work if given proper instructions. They should not be counted as laborers, but as beginners or apprentices. Naturally they will get laborers' pay and if they do not show any inclination to advance beyond such a position they should not be kept beyond a very few months. After this probation, if kept in service, they should not be discharged without an investigation by the head of the department.

If the men in the gang are not congenial and willing to work together as a team, an effort should be made to locate the reason and change the men around or to discharge those who are not willing to pull with the rest. When there is friction in a gang there is always some cause and this should be located and removed.

It is not to be expected that any method of handling men will eliminate all dissatisfaction for the millennium is not yet at hand and while human nature is what it is, there will be men who look on every action of their superiors with suspicion. However, if the gang is treated in the spirit of fair play, the majority of the men will play fair.

The gang must be made to pull together, for coöperation is the real reason for working men in gangs. The older men should be given charge of the apprentices and if the gang is large enough it should be divided into groups of five or six men each, each group in charge of one of the older men, who, in addition to being a good workman, has shown some of the qualities of leadership. The foreman looks to these leaders to keep their fellow workers properly employed and these leaders are at the same time in training for positions as foremen and should be given an opportunity to familiarize themselves with the bookkeeping required of foremen. It is not to be expected that all of these men will make good foremen, but enough of them will have the proper qualities to provide a plentiful supply of foremen and it will not be necessary to go outside of the employés to secure them.

In picking men for foremen, what qualities should be looked for? A man should be fair-minded, and patient, and a good judge of human nature, in order that he may treat his men properly and secure their respect and confidence. He should have the courage of his convictions, be energetic and resourceful, and have sufficient red blood to be a leader. At the same time he should be quiet, firm and cool-headed so that neither he nor his men will blow up in an emergency. The loud-mouthed, profane driver may be necessary with mules or oxen, but he is out of place with intelligent human beings. He should be honest, loyal, painstaking, reliable, sober and willing, so that he may be a fit representative of the company that employs him and command the confidence of his superiors. He should be studious and observing, so that he may advance in his profession and become capable of added responsibility.

In considering the handling of men it may be well to remember a few established principles. There is a limit to a man's horsepower or to the amount of work that can be gotten out of him. The value of a man does not lie in his physical force, but in his mental capacity of ability to coöperate with other men using heads as well as hands. The system of handling men and work should be such that it would not depend on any individual to carry it out. There is no use in keeping a man who is not satisfied with his job and whose work is not congenial.

Foremen should be developed along definite lines and where the system is in proper effect this will be accomplished by making a future foreman under-study the regular foreman. It is also advisable to have a future foreman placed directly under the eye of the supervisor for a time, so that he may be advised and instructed in details that otherwise might be overlooked.

In educating men for foremen, the following points should be given consideration: A foreman should know that he can not do all of the work himself, and that it is useless to try; neither should he think that because he is foreman that he should not do any manual labor. The amount of manual labor that a foreman should do has always been a matter of argument, but common-sense will show that this depends on the number of men in the gang and the class of work that is being done. The foreman in the gang is employed to see that each man in the gang does his share of the work and the nearer this result is attained the more efficient is the gang.

It is neither possible nor desirable that a foreman be given strict rules and instructions for every class of work, because this will result in making the foreman a mere machine whereby he will lose all of his individuality and self-reliance and will have no use for his head. A foreman should be given enough lee-way so that he will not lose his enthusiasm, but will feel that the work depends on him and not on the fact that he is carrying out some one else's ideas and instructions.

The successful foreman is the one who keeps harmony among the men, and who has his men "pulling for him" and not "bucking" him at every opportunity. His men work "for him" and not "because of him." A good foreman does not have to stand over his men and drive them with threats, neither does he have to discharge a man occasionally to make the others fear him. No man has ever accomplished much through fear.

A foreman should arrange the work so that there will be competition among the men: Have groups of men at the same kind of work so there will be a speed contest. This contest may only be sub-conscious, the men hardly realizing that there is a contest or any rivalry, but it will result in an increased amount of work. It must be remembered though, that it is the steady, regular stroke that counts and that spectacular bursts of speed usually "fizzle" before long. These "high-speed plays" are all right if the work is of an emergency character and will be over in a few hours, but as a steady thing they are out of place. A man may be ambitious enough in the morning, but a few hours' steady work with a "number two" will serve to subdue his energy. It is the man who can select a gait at which he can keep all day that accomplishes the most.

Neither is it the noisiest foreman that is the most successful. The noisy foreman is disappearing. We remember the old-time "walking-boss" who could be heard any time of the day over any distance less than three miles, but a cool survey will show that the quiet foreman who tells each man quietly what to do, and gives the man a chance to do it, is ahead at the end of the week. This has been demonstrated often enough to prove it to practical men, but still, some of the superior officers are sometimes misled by the spectacular "grand-stand" plays made by some foremen when the stage is properly set. This often results in these men being promoted on undeserved reputations, but they soon "blow up" because this great enthusiasm can not be kept up as a steady gait. A foreman should not permit his men to divide themselves into factions, neither should he keep the quarrelsome man or the agitator, but he should endeavor to keep the men satisfied and congenial.

The foreman should realize that he is not being paid for muscle or a strong back, but for his head and what there is in it, and he should employ every opportunity to use his head to save hard work. Human energy uselessly expended can not be replaced and it should be conserved wherever possible or economical. To conserve and make human energy effective, tools have been developed. Without tools little can be accomplished, so it is a waste of labor to try to work without proper tools. These tools are of two general kinds, hand and mechanical. The hand tools may not be exactly labor-saving but their use makes labor effective and they should be of the best class obtainable. Keeping them in proper shape is a great aid to efficiency. Is there any greater pacemaker in sawing off a pile than a good sharp saw properly set, or is there anything that will take the heart out of a man so quickly as a dull, poorly set saw? This applies to all other tools, and there is no doubt but that the time used in keeping tools in shape, is time well spent. The other class of tools is the mechanical. These are labor-saving tools and permit of steam or other power doing the work which would otherwise have to be done by men. Of course, economy should be taken into consideration, as it will not pay to set up a concrete mixer to mix a few yards of concrete, or an air compressor to drive a half-dozen rivets.

Labor saving devices have been greatly developed during the past 25 years and have reached a stage where a small gang, properly equipped, can do a great deal more work than a larger gang without proper facilities. The principal labor saving tools used in ordinary Bridge and Building work are the locomotive crane, the car pile driver, the hoisting engine, the concrete mixer with its appurtenances, the gas engine, steam and gasoline operated pumps, pneumatic riveting and boring tools, gasoline motor cars and jacks.

The locomotive crane is too expensive a tool for the ordinary bridge gang, but there should be enough on each supervisor's district to provide this equipment where needed. The modern car pile driver is a very efficient machine and each railroad should have enough to do their ordinary work and take care of emergencies. These drivers should be placed in the hands of efficient men and worked to as nearly full capacity as possible as it does not pay to have them idle. With suitable attachments they can be used as light car derricks and their sphere of usefulness enlarged.

Almost every bridge gang can find efficient uses for a hoisting engine and their use should be encouraged. The gasoline engine has been developed to such an extent that it is very reliable and the present day workmen are so well acquainted with it that there is no difficulty in finding someone to run it. It is very satisfactory for operating pumps, concrete mixers, etc. Probably the greatest labor saving device of the present day is the concrete mixer. An average bridge gang doing ordinary work will have considerable concrete to mix and to do it by hand, especially with men not used to it, is a back-breaking job. It is impossible to keep good mechanics if they are put at this kind of work very often. The small mixer taking a one-bag batch is the best for an average bridge gang. It should be self-contained and require no great amount of time to set it up. A mixer mounted on wheels or skids with a gasoline engine directly connected to it is best. It is almost criminal to mix concrete by hand when power is available.

Pneumatic riveting and boring tools are not used by the average bridge gang, but every gang working on steel bridges must use these tools to do good work. They are not only economical but rivets driven by pneumatic hammers are better than those driven by hand and greater dependence can be placed on them. The motor car also adds greatly to the efficiency of a bridge gang as the men can be taken to their work in less time and are in better physical condition when they get there. A bridge gang should be supplied with good jacks of proper sizes. The modern, ball bearing screw jack is probably the best all-around jack, but each gang should also have some ratchet jacks for such work as they are suitable for.

The furnishing of the tools is the duty of the superior officer, but their upkeep depends on the foreman. With proper tools and men, a gang is ready to go to work and its efficiency depends on how the men go at it. If they arrive at the job late in the day do they go to work, or do they fuss around, so as to make a start in the morning? Has the foreman any definite idea as to how the work is to be undertaken? Where a gang is employed on one kind of work it is easy to get the job under way, but where the work varies in character, it is usually hard to get a start at it, so as to keep all hands profitably employed. This is where a competent foreman can make a good showing and on the amount of headwork he uses, will depend the efficiency with which he starts his work.

The foreman will soon realize that although all men are born free and equal they do not remain so long enough to work for him, and although all of his men may be good, there may be some of them better. Neither are all men equal in the variety of work they can accomplish.

A good axeman may not be a good sawyer, and a good sawyer may not know, or care, what the little marks on the square are for. Neither are all men equally painstaking as one man may level a structure closely where another will be away off, and still the painstaking man may not be the most efficient, because it might not matter whether or not the structure was level. Having these men of different characters and propensities, it is the foreman's duty to see that each man is put at what is most suited to him, where possible, and on his ability to do so, his efficiency will greatly depend.

A foreman should not carry more men than he can work to the best advantage. This can not be a hard and fast rule, but will depend on the average class of work that the gang is employed at. If the gang is at work requiring 16 men, and is stopped somewhere on the road to do a job requiring 6 men to handle it to good advantage, 10 of the men can not be laid off with the expectation of picking them up in a day or two. Still, the use of the larger gang may show the greatest ultimate economy, as it might be necessary to move a smaller gang some distance to do the work. This lack of economy is, in reality, largely imaginary, as a good foreman can usually work all of his men to advantage.

A foreman should be even tempered and train himself not to fly up in a rage when things do not go to suit him, and he should not reprimand the men publicly. If a man is any good at all, he has pride and self-respect, and even if he is wrong, he dislikes being told of it before his fellows. A foreman should also be careful to avoid doing one of his men an injustice. It is not enough to be just; some things are better forgotten or overlooked. Perhaps if all could realize that they are fellow employés and that all are human, much of this paper need not have been written. An old saying is, " A soft answer turneth away wrath." A more modern saying would be, " A little blarney is better than a jacking up." The secret of efficient man-handling lies in education, supervision, loyalty and coöperation.

The department must have a head, and on this officer depends the efficiency of the division. To fill this position properly, a man must have special training and experience. He must be familiar with all the building trades, keep up to date in the use of tools and labor saving devices, and be an expert in the art of handling men. He must have all of the qualifications required of a foreman and in addition he should have the necessary qualifications to enter the diplomatic service. He must have backbone enough to stick up for the rights of his men and the necessities of his work and to see that he gets a fair share of the available money. His success depends on the regard in which his subordinates hold him much more than that of his superiors.

In handling men the most successful supervisor is the one who knows each man under him well enough to call him by his given name. If the men hate to see the supervisor come around, one may be sure that there is something wrong in his make up. He should keep himself informed regarding the family affairs of those under him and enjoy the confidence of them all. He should see that his foremen understand his desires as to how the work is to be done, and, as few foremen are mind-readers, he should tell them explicitly. He should not talk too fast, but go slowly enough to permit the foreman to be somewhere within a few laps of him.

It is always best to let a foreman handle the details of the work in his own way, if his way is anywhere near right, but there should be a clear understanding in regard to it, so that the work may go on properly from the beginning. Once the work is outlined, proper material and tools should be provided and enough material for a good start should be on hand before the gang is started at work. Much inefficiency is the result of not having material and tools when required.

He should go over the plans with the foreman and see that they are understood. He should see that the foremen are provided with everything to prevent the men from injury and that it is used. Men do a great deal more work if they have safe staging, stairways, etc., and are relieved from anxiety while at work. It is useless to expect a man to swing a hammer over his head if he is afraid of falling off a plank. He must have a good footing to do good work.

The supervisor should see that his men know how to tie the standard knots and that they have rope of proper sizes. His men, especially the foremen, should know what a rope is good for and in order that there be no misunderstanding in regard to it a table giving the strength of rope should be posted in the tool car where all can see it. The other duties of a supervisor along this line are obvious, and may be stated by saying that he and his men should know their business. A system of cost accounts tends greatly to efficiency. Each foreman should be required to report the labor cost of each job done and the costs of similar work by the same or other foremen should be compared. It is not sufficient that these costs be taken from the auditor's accounts. They should be furnished by the foremen, as the fact that the foreman must work up the statement will cause him to be more careful in the handling of the work.

A supervisor should have gangs of the proper size, properly equipped and located at the most convenient points so that there may be no great loss of time in moving them around. These gangs should be organized to do all work of an ordinary character in their territories. Special gangs should be provided and specially equipped to handle the larger jobs of construction and reconstruction and such other unusual jobs that require special training and equipment.

In the opinion of the committee, the greatest incentive for men to do a good day's work is to have plenty of work in front of them. It is almost impossible to do efficient work when the job is about finished and no other work is in sight.

With the men, foremen and supervisors efficient, any other efficiency must come from those higher in authority. The officers whose duty it is to supply the plans should make them complete and in sufficient detail so that there will be no guess-work in carrying them out. Standard plans should be provided as far as possible and all structures should be built to these standards whenever possible. Standard bills of material should be made and material of the proper size ordered and furnished. The bridge and building officers should keep in close touch with the supply department, and the more confidence these departments have in each other, the better service the bridge and building department will get. The supply department does not employ any mind readers.

The next, and most important, of all points tending to efficiency is regularity of employment. It is useless to try to perfect an organization if it is to be broken up every winter or, as soon as the earnings fall off temporarily. When the operating officials arrange so that the work can be carried on continuously and employment made permanent then, and only then, will there be a real foundation on which to build an efficient organization.

Finally, we must not lose sight of the fact that the real business of a railroad is to provide transportation, that all other work is only incidental thereto, and that we must not allow our efficient methods to interfere with the running of trains. We have no money to waste, but it is nearly always necessary to depart from the most economical methods to avoid delays to trains. Consequently we must consider efficiency to mean—the most satisfactory method of conducting a railroad as a whole.

SUBJECT NO. 7.

WARNINGS FOR OVERHEAD AND SIDE OBSTRUCTIONS.

REPORT OF COMMITTEE.

The necessity and the value of giving proper warning to men on top or on the side of cars before passing overhead or side obstructions on railroads is evident. When a train passes some overhead or side structure, tunnel, etc., with less than the requisite overhead clearance to allow a man to stand erect on top of the highest box car, or the necessary side clearance to permit him to hang on the side of a car; his limb or life is jeopardized.

This report is a continuation of Subject No. 2, " Warnings for Overhead and Side Obstructions " of last year, embodied in the proceedings of the convention held at Los Angeles in 1914 and refers more particularly to side obstructions; therefore, warnings for side clearance only will be considered.

Letters were sent to the chief engineers of the various railways in this and several other countries asking for any information and plans regarding the construction and cost of side warnings used by their respective roads. Only one of the replies was really satisfactory—that from the Baltimore and Ohio—referring to side warnings used by that road, and illustrated on Page 125 of the 1914 proceedings. Several other replies indicated that the roads were seriously considering the subject and were endeavoring to produce satisfactory devices but up to the present time they have not succeeded. Others informed us that they do not need any overhead or side obstruction warnings because they take precautions when constructing any structures, to provide ample clearances to insure safety to employees and the public.

The description of the construction of the side obstruction warning used by the Baltimore and Ohio is as follows:—

An iron post is set in a vertical position; to this post are attached a number of wooden blades, each provided with one rubber end, by means of iron rods which operate by springs in both directions so that, when a man comes in contact with the blades, the warning will swing either way and come back to its normal position. The cost of constructing such warning is $7.04 for material and $14.44 for labor, or a total of $21.48, the cost of erection not being included.

With reference to any legal requirements specifying clearances for overhead and side structures on and along railroads, we are informed that only four states have enacted legislation regulating the requirements for side clearances and ten states regarding overhead clearances. The following is a tabulated summary of the statutory requirements of the several states which enacted legislation as to railroad clearances:—

State	Overhead Clearances Above Top of Rail.	Side Clearances from Center of Nearest Track.	Width of Bridges
Connecticut	18 ft. 0 in.		
Ohio	21 ft. 0 in.	18 in. from locomotive cab	
Indiana	21 ft. 0 in.	7 ft. 0 in.	
North Dakota		8 ft. 0 in.	
Kentucky	22 ft. 0 in.		
Minnesota	21 ft. 0 in.	8 ft. 0 in.	
Mississippi	23 ft. 0 in.		
New Hampshire	21 ft. 0 in.	8 ft. 0 in.	
Rhode Island	18 ft. 0 in.		
Michigan	7 ft. above roof of freight cars passing over line.		
Vermont			Single Track 15 ft. 0 in. Double Track 27 ft. 0 in.

There has been a tendency in the past few years to enlarge the side clearance diagrams for bridges, but, until the maximum size of motive power and equipment is established by legislation or other method, there seems little relief in sight by reason of the enlargement of the clearances. It is an acknowledged fact that, up to this time, the size of motive power and equipment has closely followed the available clearances and this will, no doubt, continue until some restraint is placed on the enlargement of the motive power and equipment.

E. G. Storck,
F. E. Schall,
T. E. Thomas,
M. M. Barton,
Committee.

DISCUSSION.

(Subject No. 7, Warnings for Overhead and Side Obstructions.)

J. N. Penwell:—We have adopted the side and overhead clearance on the Lake Erie & Western required by the state of Indiana. It will be noticed on the second page of the report that the clearances that are provided are tabulated in a very concise manner. The Lake Erie & Western had already established a 20 ft. vertical clearance and a 7 ft. side clearance previous to the enactment of legislation. We have what we regard as some very foolish legislation in Indiana, but this is one law that I think is really important and which did some good, because the side and overhead clearances on any railroad are very important factors in protecting life. It cost us considerable money to get this clearance, but it was just what we were expecting to do and we had the work well under way.

I do not know whether this committee has said anything in regard to the distance from the structure that the warnings must be placed; some of you may be prepared to go into that a little later. On our railroad we decided that from 125 to 150 ft. from the structure would be the proper distance to place the warning. The Indiana legislators, who had probably never figured on the time it took a train to run 100 feet at the rate of 40 miles an hour, decided that we were wrong and compelled us to move our warning guards, placing the limits at from 75 to 100 ft. Consequently all our warnings had to be moved. I thought that was rather foolish because I felt that the railroad officials had given the subject more serious thought, and had taken into consideration the speed of the trains and the distance of travel more thoroughly than our legislators who had never studied railroad problems. This is referred to as one of the foolish moves, but the clearance law is an important one. All railroads should work to that end without any legislation.

The President:—Mr. Eggleston said he had some data on side clearances that had not been incorporated in this; I think we ought to hear from him.

W. O. Eggleston:—The Erie has a side clearance sign placed at the object where the proper clearance does not exist. The sign is painted a white back ground with red letters, reading down vertically, and spelling " Danger."

S. C. Bowers:—Don't you think the center fences between tracks ought to be taken into consideration in securing this protection? Many men get down to look at a hot box or a brake and are hit by the center fences between tracks. We have had three or four injuries, and one or two deaths on our division.

P. J. O'Neill:—What are your track centers?

S. C. Bowers:—Thirteen feet.

J. S. Robinson:—We had a case where we had put up side warnings for a truss bridge near the headquarters of a fraternal society to which 3,000 or 4,000 excursionists come every year from all parts of the United States. We were afraid they would strike this truss by leaning out of the car windows, and we devised a post with old rubber train hose for the whips, but we ran into a patent gotten up by a bright Californian and we had to give it up. After considerable discussion we placed these 50 ft. and 150 ft. on each side of the structure—it was a single track road—and found they were very efficient. I have forgotten the name of the patentee but the device consisted of an iron post with four or five of these arms sticking out. I think they were of wire with a cork ball on the end.

E. T. Howson:—The railway brotherhoods are conducting an organized campaign before the different legislatures to secure increased clearances. One of the recent rulings on this subject is that of the Illinois state railroad commission, which has established a tentative side clearance of 8½ ft. from the center of track or 17 ft. total clearance on single track. The railways, through their associations, have been very backward in adopting standard clearances, and as these demands on the part of the railway employees for clearances come to the commissions or legislatures they can go to no railway association to find any agreement between the railways as to what they consider standard clearances. I think partially because of that fact, some of the clearance regulations are as strict as they are; they are going beyond what any railroad man would suggest. This subject came up before the American Railway Engineering Association last winter; it has been up before that association previously, but owing to the opposition of many of the members, the recommendations were voted down; consequently, that association also has no recommendations. I believe if the proper railway associations would go into this matter thoroughly and recommend a fair clearance, not a clearance so small as would take in all the railroads, because some of them have conditions that I don't believe any railroad man would defend—but regulations that would be fair, many of the state legislatures and commissions would adopt those and it would hasten uniformity.

It is not only a source of safety but it becomes a source of real danger when clearance regulations change at the state lines. The average railroad map absolutely ignores state lines and if there is a clearance of 7½ ft. in this state, 8 ft. in the next and 7 ft. in some other state, there is confusion; the train men are apt to think they are on a portion of the line where the 8 ft. clearance exists and they may be struck by a structure in a state where the clearance is 7 or 7½ ft.

The last paragraph of the report raises a question that frequently comes up in the minds of maintenance of way people regarding the advisability of increasing clearances. They say that as soon as the clearance is increased, the mechanical department takes advantage of that to build larger equipment, so that the relative relation is the same. That is true, but at the same time, the purpose of a railroad is to operate as economically as possible. If larger motive power and larger cars will reduce the cost of operation by an amount greater than the fixed charges on the outlay necessary to increase the clearances, and provide the heavier equipment the railway, which is paying the salaries of those in all departments, gains, and it is this final result that should be taken into consideration. The question is not one between the departments, but rather as to what is best for the railways as a whole.

G. W. Rear:—It would appear to me that there should be some difference between side clearances out on the road and around terminals. There is absolutely no excuse for any trainman riding on the side of a car when the train is in actual motion between stations. The only excuse for a brakeman being on the side of a car is when he is switching. It seems to me that an effort should be made by the railroads to bring this to the attention of the regulating authorities, because it is going to put a great hardship on the railroads if any regulating body forces a very wide clearance for bridges which are away from stations.

I note that the legal requirements of California are not shown in the report but they have been established. We find that one of the best features of these legal requirements arises where a county or municipality wants to put a street or a highway overhead. There is a fixed clearance limit so that we don't have to argue with the commissioners as to the height of the structure. Otherwise usually this is a matter to be fought out between the railroad and the state or county. There is a tendency on the part of the man who is paying his half of the cost to want to keep the structure down, but where there is a state requirement there is no argument.

J. N. Penwell:—I wish to say in regard to the clearance required in Indiana that this was also put into effect at once in Illinois and Ohio through which states we are operating. Our legislature in Indiana also requires a certain clearance for water tank spouts, etc., which was a very sensible and a very conservative requirement. As soon as that law went into effect in Indiana, we complied with it and issued instructions immediately that the same requirements be put into effect in Ohio and Illinois, for the protection of our trainmen because, as Mr. Howson said, with a man crossing a state line from one water tank to another, with the spout of one high and of the other low, this condition becomes more of a menace than to have all alike on a low clearance; so wherever our railroad operates, regardless of the state lines, we have a uniform clearance.

There are a few cases where we have not the same side clearance, where we would have to buy property which is extremely hard to get hold of. I want to advocate sufficient clearance from many standpoints; first and most important of which is the protection of our fellow workers on the railroads. Another point that Mr. Howson brought out is the widening of the equipment. The mechanical department don't wait for us to get ready for these things, but it goes ahead and buys the engines, as was the case on one of our eastern railroads a short time ago where a lot of engines were bought and shipped, after which the bridge engineer was given a chance to prepare some figures. The result was that 13 or 14 bridges had to be rebuilt before the engines could be used, and the engines lay in the round house for months. The same thing is true in regard to our round houses; the equipment comes and then we have to make preparations to care for it. The further in advance we make preparations, the easier it is for us when we get the heavier equipment, and when we are widening our clearances we are working toward standards we must ultimately establish for the protection not only of the employees but of the property of the railroads.

SUBJECT NO. 8.

REINFORCED CONCRETE BRIDGES.

REPORT OF COMMITTEE.

The first report of this committee was made to the association at the 1914 convention in Los Angeles. That report was prepared after a canvass had been made of all the representative railroads of the United States and Canada. It showed to what extent reinforced concrete was employed in railroad bridge work, the types in most general use and the specifications governing the design, materials and construction. At the convention it was decided that this committee should be continued for another year, in order that it might report on field practices and methods of construction of reinforced concrete work.

The committee took up the work of 1915 in accordance with the instructions of the association, by sending to 42 railways that had reported building reinforced concrete work in 1914, a circular letter requesting information on methods and practices which were different on various roads. This circular letter contained the following questions:

1. Describe the methods and equipment used in placing slabs.

2. Describe the methods and equipment used to place concrete in the field—(a) by company forces; (b) by contract.

3. Describe how work train service is used to handle material.

4. Describe methods of concreting in cold weather and of protection against frost.

5. Advise if it is your practice to make test cubes of concrete during the progress of the work.

6. Is the spouting of concrete permitted, and if so, under what restrictions regarding the slope of the spout or the distance spouted?

7. What precautions are taken to insure thorough mixing?

8. What measures, if any, are taken to minimize the amount of air in the mixture or to expel it after the mixture is deposited?

9. Advise if the cement gun (using compressed air) or the atomizer (using steam) has been used in construction or in maintenance. If so, have the results been satisfactory?

10. How is the proper time for removing forms determined under varying conditions?

11. Give any other information which would be of value to the committee and to the association in connection with reinforced concrete bridges, with particular reference to field and construction methods.

In addition to the above questions, two tables made up from data received in 1914, were sent to each road to be verified. One of the tables was the designing data on deck slabs, part of which appeared in the 1914 report (see Fig. 2 of that report). The other was the table of the types of structures in use on each railroad. This resulted in the correction of some errors that had appeared in the report on deck slabs in 1914. It also showed that some of the railways were constructing more types in 1915 than in 1914. As the committee sent no inquiries to roads that reported no reinforced concrete structures in 1914, it has no means of knowing whether the number of roads constructing such structures has increased

The field practice and construction methods applying to reinforced concrete involve so much that is common to both reinforced and mass concrete, that it was found impracticable to make the inquiries so that they would apply to reinforced concrete only. This should be kept in mind in noting the replies from the different railways.

The reports from 36 railroads show that there is a wide divergence of views on some of the questions and a great variation in methods intended to serve the same purpose. This was anticipated. The questions were made up to cover those matters on which there was little or no uniformity. The replies received from the railways are given below, listed under the questions to which they apply. At the head of each list the replies have been summarized so far as it was found practicable to summarize data of this character.

Describe Methods and Equipment Used in Placing Slabs.

Three methods of procedure are common: (a) Constructing slabs at a central point, hauling them to the bridge site on flat cars, and setting them in place with a derrick or wrecker; (b) Building slabs at the bridge site at the side of their permanent location, and skidding them into place; (c) Where there is sufficient head room, the slabs built at the bridge site are, of course, constructed in place. Fig. 8, in the 1914 report, shows how the E. P. & S. W. builds slabs in place close up under the rail.

There is a decided preference for casting slabs at a central point and lifting them into place. Fourteen roads with a mileage of 64,700 follow this method, while 11 roads, with a mileage of 31,000, report building slab at the bridge site.

Atlantic Coast Line;—Flat cars are used to haul slabs from the slab yard to the bridge site. A derrick is used to handle them at the slab yard and a wrecker or bridge derrick is used for placing them. On a double track line the erecting car on one track places slabs on the other track. On a single track line the slabs are swung to the front of the erecting car and placed, the car moving forward as the work progresses.

Atchison, Topeka & Santa Fe;—In a very few cases the slabs have been moulded at or near the bridge site. In general, it is expected that the slabs will be moulded at a central construction yard. In erecting slabs, a heavy derrick car or a wrecker is used. No other special equipment is required, except the bridle and lifting device.

Baltimore & Ohio;—Steel spans are usually placed at one side—forms are built—the concrete slabs are cast and allowed to set; they are then waterproofed, and the completed span pulled or rolled into its final position.

Canadian Pacific;—Slabs are usually built in place on timber forms, although they are sometimes premoulded. They are either lifted with derricks or skidded into place.

Chicago, Milwaukee & St. Paul;—Heavy trestle slabs are placed either with one 50-ton or two 30-ton erection derricks. Smaller slabs and deck girder slabs are handled with the regular steel erection equipment. Slabs that are too heavy to handle with the available equipment are erected on falsework on one side of the bridge, slid into position on girder carriages and then lowered to their beds with jacks. In some instances, use has been made of wrecking derricks for setting slabs. At one time, a special device consisting of a 75 ft. girder span mounted on two cars was used to handle heavy slabs and distribute the load over a sufficient number of axles, the slab being suspended from the middle of the girder and handled by drums on cars at either end of the girder.

Chicago, St. Paul, Minneapolis & Omaha;—The railway furnishes a derrick car and the slabs are lifted into place.

Cleveland, Cincinnati, Chicago & St. Louis;—Slabs are usually built in place. In a few instances they have been premoulded and set in place with a derrick.

Chicago & Northwestern;—Slabs are usually built at a central yard, shipped to the bridge site on flat cars, and set in place with a derrick car used for steel bridge erection. Occasionally a wrecker is used on very heavy slabs. Slabs for culvert tops are built in place when there is sufficient headroom for construction.

Delaware, Lackawanna & Western:—Two methods are in use; casting slabs in place; and casting them in units and setting them in place with a derrick.

The conditions governing the use of the first method are (a) the renewal of a bridge on the same alinement, while maintaining traffic on all tracks. Where the span is not too long, a temporary trestle to carry traffic is built to clear the finished structure. The slab is then built under traffic. Where long spans of a new structure prohibit the construction of a trestle, the tracks are shifted temporarily beyond the limit of the structure. (b) The renewal of bridge on same alinement with traffic closed on one track: The slab is built in sections 13 ft. wide, under the closed track. This method obtains only on large construction, where the forces can be moved to some other part of the work during the time allowed for the concrete to set. When the concrete under the closed track has set, a different track is closed and its traffic diverted to the track on the finished slab. (c) The renewal of a bridge or new construction on a change of alinement: Such work is generally constructed by contract. Company forces are usually employed where the construction interferes with traffic.

The conditions governing use of the second method are where unit construction is used where traffic must be maintained on all tracks without interruption for any length of time without change of alinement.

Duluth, Missabe & Northern;—Concrete slabs are placed with derrick cars. Slabs 22 ft. long and 12 ft. wide, weighing 60 tons have been placed, using a 75-ton bridge erecting derrick.

El Paso & Southwestern;—Slabs are built in place in one piece (See Fig. 8 in 1914 report of this committee). This method necessitates the construction of the piers and abutments first, and a return to the work after they have hardened sufficiently. It is considered that the advantage of building the slabs in place in one piece justifies this procedure.

Great Northern;—Slabs are usually placed by company forces, using wreckers or convertible cranes. When slabs are placed by a contractor, a steel erectors' derrick car is used.

Illinois Central;—Before placing the slabs of concrete trestles, a layer of mortar consisting of 1 part cement and 2 parts sand is placed on the piers and on the bridge seats of abutments, to insure a uniform bearing of slabs. A ½-inch expansion joint is left between the ends of abutting slabs and a 2-in. expansion joint is left between the ends of slabs and the parapet walls of abutments. No space for expansion is left in joints parallel to the tracks. Joints between slabs and parapet walls, the joints over the piers, and joints parallel with the track are filled with a mastic composed of 1 part pitch and 2 parts sand, with enough oakum to close the ends of the joints at the abutments and piers, and the bottoms of the joints, parallel to the tracks.

Kansas City Southern;—Slabs are constructed with lifting bolts embedded in the concrete, and are set in place by a derrick or a wrecking crane.

Lehigh Valley;—Slabs are set with locomotive cranes or skidded into place on rails.

Long Island;—This road does not use premoulded slabs, believing that a steel frame costs but little more, and is more conservative than reinforced concrete alone.

Louisville & Nashville;—Slabs are placed with a wrecker or derrick, using two hooks and a steel spreader.

Missouri Pacific;—Slabs are constructed in place, or moved into place on rollers.

Nashville, Chattanooga & St. Louis;—Where slabs can not be built in place, they are usually built on timber bents and moved into place on rollers.

New York, Ontario & Western;—Small slabs are skidded into place on greased rails. Large slabs are built on rollers and rolled in.

New York, New Haven & Hartford;—Very little of this work is done. Slabs are cast in the vicinity of the bridge and lifted into place with a derrick.

Oregon-Washington Ry. & Nav. Co.;—All slabs are constructed in place.

Pennsylvania Railroad;—Slabs, other than those for deck girders, are cast at some central point, or at the bridge site, and after seasoning are lifted into place with a derrick. Slabs for deck girders are usually cast in place.

Pennsylvania Lines West;—Slabs ordinarily 6 ft. 6 in. wide and of the required length are constructed at the bridge site. An eye bolt for lifting is embedded in the concrete. After slabs are seasoned, they are placed by a derrick or wrecker.

Describe Methods and Equipment Used to Place Concrete in the Field.

The reports show a general preference for mixers of the batch type, and wheelbarrows or dump cars for moving, with special equipment where the work is of such magnitude as to justify it. Hand mixing is not much in favor, but is done on most roads on jobs that are too small to justify the use of a mixer.

Atlantic Coast Line:—Where the work is done by company forces the equipment includes batch mixers, cement storage cars, tool cars and shanty cars, which is set on a siding convenient to the work. Sand and stone are unloaded through drop-bottom cars at the site of the work. Slabs are moulded in a slab yard at a central location. Where done by contract the procedure is the same as for company forces. The road prefers to do all work of this kind by company forces.

Baltimore & Ohio:—On company work, when practicable, mechanical mixers of an approved form are used. The concrete is either wheeled or spouted into place. On contract work the methods and equipment are optional with the contractor, but must meet the approval of the railroad company's engineer.

Chicago, Milwaukee & St. Paul:—The methods employed and the equipment used in placing concrete vary with each individual job. Concrete dump cars running on light rail, spouting, tremies, concrete buckets operated by derrick and locomotive cranes, concrete hoists and elevators, belt conveyors, and ordinary concrete wheelbarrows are employed. Tremies are used to place concrete under water and a form of tremie is employed where the concrete has to be dropped from any considerable height.

Big Four:—On company work the mixing is done with a mixer, usually set at the track level. The concrete is spouted direct to the forms or wheeled in wheelbarrows. On contract jobs the work is done in a manner similar to that with company forces, but a contractor's equipment sometimes includes a derrick and buckets. Also, where conditions warrant, tram cars have been used, running alongside the railroad track on extensions of the deck to reach distant piers or abutments. In but few cases have extensive spouting systems been set up.

Chicago & North Western:—Slabs are usually built and placed by company forces. The equipment includes a machine batch mixer, and wheelbarrows for delivering material to forms. Some of the jobs are built by contract, the methods and equipment being left to the contractor, so long as proper facilities for inspection are provided, and the results are satisfactory.

Delaware, Lackawanna & Western:—Contractors' plants are sometimes located alongside the tracks and the concrete is deposited by means of a derrick, wheelbarrow or small chutes. Where sidings can be built alongside the new construction, the mixing plant is mounted on flat cars with the sand and cement on the train. On large viaducts recently constructed by contract two methods have been used for placing concrete; one, the construction of a cableway over the center line of the structure and the other by derricks. The latter method was used in the construction of the viaduct 1,000 ft. long and 120 ft. high, with three positions for the derrick: (1) The piers were built to the springing line of the arch with the derrick on the ground; (2) the arch rings and center section of the floor were constructed with the derrick moved to a platform on top of the pier; (3) the pilasters and floors were finished with the derrick on the center section of the floor.

The largest concrete structure, the Tunkhannock Creek viaduct, 240 ft. high and 2,375 ft. long, consisting of ten 180-ft. and two 100-ft. semicircular arch spans, was built with a double cableway located over the center line of the viaduct. The arches were built in two ribs, 6 ft. apart. The structural steel centers used in the construction of these arches were supported on 4-ft. offsets on the piers, 17 ft. 6 in. below the springing line. The same centers were used for the two parallel ribs, the 6-ft. opening between the ribs permitting the moving of the center to the next span by the cableway. The centering ledge was 90 ft. above the surface of the ground on the highest pier.

For unit construction the abutments and piers are built between the bents of the temporary trestle carrying the traffic. The slabs are cast away from the site and set in place by derricks between train movements.

Great Northern:—Practically all work in the field is done by contract. The methods and equipment are left to the contractor, subject to the approval of the chief engineer. All piling is usually furnished and driven by company forces. The company also furnishes reinforcing steel and cement.

Illinois Central:—On company work mixers are used when the work is large enough to warrant, usually 300 yards or more. Hoists are used when it is not feasible to handle the concrete from the end of the bridge with tram cars. Portable cement houses are used. When suitable second-hand material is available, floors are laid for storing stone and sand. All heavy equipment, such as mixers, pumps, derricks, engines, etc., are distributed to best advantage over the entire system under the direction of the engineer of bridges and buildings.

Contractors handle work in accordance with the specifications and usually furnish all material and equipment. Occasionally, foundation piling and temporary tracks are furnished by the railroad. Falsework is handled by company forces.

Kansas City Southern:—On company work mixing is done by hand and concrete is wheeled to the forms in wheelbarrows. Slabs are cast at the bridge site and swung into place by a derrick car operating on the track.

Long Island:—In placing concrete with company forces the mixer is ordinarily set below the level of the runway to allow a level or descending approach for the wheelbarrow delivery of materials. After mixing, the concrete is raised by buckets inside of a tower, dumped into a hopper and thence as required into barrows or spouts. Spouting has been done only for short distances, however. For runway construction, a pair of 30-ft. rails carrying wooden cross pieces, which in turn support longitudinal planks, has been found efficient and economical.

Michigan Central:—Almost all work of this character is done by company forces. In general, the equipment consists of a ½-yd. mixer with an elevator, 3 small dump cars, 2 boarding cars, 2 tool cars, 2 material cars, light rails for building tracks, wheelbarrows and tools.

Nashville, Chattanooga & St. Louis:—All concrete work is done by company forces. The concrete is mixed in mixers with charging hoppers, and transported in 1-yd. drop-bottom tram cars.

New York, New Haven & Hartford:—For work of any magnitude handled by railroad forces concrete mixers are used and the material is placed with wheelbarrows or chutes. For small jobs, concrete is mixed by hand. On contract work concrete is mixed by machine and placed with barrows or chutes as may be most applicable to the job. Where conditions make it advantageous, the mixer is dumped into a tram car which runs on a track to the site and is emptied into wheelbarrows which deliver the concrete to the forms.

New York Central:—Practically all work is handled by contract. The equipment depends on the size of the job; but usually includes rotary mixers, with steel wheelbarrows, for carrying the concrete to the forms.

Norfolk & Western:—The track is supported on falsework above the final grade, leaving room for the concrete to be placed underneath the stringers. After setting for two weeks the stringers are removed, the ballast is placed, and the track is lowered to its proper elevation. Slabs are poured in sections complete at one operation.

Pennsylvania:—Concrete is usually mixed by machine on company work and is placed either by wheelbarrows or a derrick, depending on the condition of the work and the amount of concrete.

Pennsylvania Lines West:—In the majority of cases where the work is done by company forces the concrete is handled by a derrick and bucket. Where possible, a tower is constructed and chutes used, and on small jobs not warranting either, concrete is placed from wheelbarrows. Mixers are ordinarily used.

Contractors use towers, chutes, derricks, dinky trains and wheelbarrows in placing concrete in forms. Towers and chutes were introduced here in 1912 and very good results obtained by this method. Tower, mixer and material bins were mounted on a 16-ft. gage car which could be moved from one place to another. Material bins were filled by a locomotive crane and concrete was transferred from the mixer to forms by chutes. This method is very practical where retaining walls and bridges are close together. Where a tower and chutes are not feasible, derricks are used to transfer concrete from the mixer to forms. The material is elevated above the mixer and the concrete moved from the mixer to forms in buckets on dinky trains or in dump cars with locomotives. On small jobs which will not warrant the use of a tower or derricks, the concrete is moved in wheelbarrows from the mixer to the forms.

Southern:—The largest part of the work, particularly on maintenance, is done by company forces. Machine mixers are used on large jobs, while small jobs are mixed by hand. On contract work methods and equipment are left to the contractor, governed by full and complete specifications as to the character of the work.

Describe How Work Train Service is Used to Handle Material.

The methods of handling work trains depend largely on whether the work is being done by company forces or by contract. A large system that does the work by company forces, necessarily has its work train service well systematized. When called out, the train is kept busy during the full day. In this class of work the train has little to do beside moving the materials. Wherever possible, materials are allowed to accumulate at the nearest station until enough is on hand to make a full day's work for a train. Where this is not practicable, the materials are handled by the local freight. The material is handled by the men on the job, whether on company work or contract.

Where the work train service is for contract work, it is quite a general practice to make a fixed charge for this service. Under this arrangement the contractor can have all the train service he requests, but it will be to his interest to use it only when he actually needs it.

The differences in the work train service on the various roads appear to be due more to the difference in the amount of the service, and to the local conditions, rather than to any established practice in the handling of such trains.

Atlantic Coast Line:—A work train is handled by a maintenance of way man who has qualified under the transportation rules to handle trains. He has charge of the labor on his train and is responsible for the work done. The engine crew is the usual transportation crew. The crews carry shanty cars and tie up at night at telegraph stations near the work, where water is obtainable. Work trains must clear for traffic.

Santa Fe:—Where work is handled by contract, the contract generally assumes that the company will furnish train service without charge, or at a fixed price per day. In either case the contractor or the general foreman of bridges and buildings orders a work train through the train dispatcher and the superintendent. A work train is generally ordered in the evening for the next day. One conductor and at least one brakeman are furnished with it.

Chicago, Milwaukee & St. Paul:—Work train service is arranged for by the assistant engineer in direct charge of the work; and wherever the magnitude of the structure warrants it, spurs are put in to avoid handling material on the main line.

Chicago, St. Paul, Minneapolis & Omaha:—The railway furnishes all work train service. If only a small amount of material is to be unloaded the way freight handles it. On large jobs the material is shipped to the town nearest the bridge site and when sufficient material has accumulated to keep a work train busy all day one is furnished. The contractor furnishes all labor for the unloading.

Big Four:—Work train service is used for handling material, to unload concrete materials and to unload and load contractor's equipment in cases where a contractor's spur is not available at the site of the bridge. Work train service usually is furnished to the contractor and specified in the contract, but the company makes a decision as to what is necessary service.

Delaware, Lackawanna & Western:—Under ordinary conditions, one work train on each division handles all company work. The trains are unloaded by the workmen on each job. Where a work train is hauling material for contractors, it is unloaded by the contractor's forces.

Duluth, So. Shore & Atlantic:—Most of the work train service is done by local freights.

Great Northern:—All work put in is charged with the work train service used in connection with carrying out a particular piece of work. Where work is done by a contractor this has been handled in two ways; in the first method the railway furnishes free work train service, the amount furnished in such a case being controlled to a certain degree by the engineer in charge to prevent the contractor from abusing this privilege. The second method requires the contractor to pay for all work train service which he requires, at a fixed price per day. In this case, the work train service is charged to the work in an indirect manner, as the contractor includes this item in his price for carrying out the work.

Illinois Central:—Work trains have complete train and engine crews. Train crews do all flagging and handling of switches. The spotting of cars is handled by the foreman in charge of the work, through the train crew. The movement of trains over main line as instructed by the foreman is handled by the train conductor who is governed by the usual train orders. When a derrick with propelling gear is on the job it is handled with a train crew and moves cars for unloading.

Kansas City Southern:—On large jobs material is allowed to accumulate until there is enough to provide a work train a full day's work. On small jobs, it is handled by local freight.

Lehigh Valley:—A work train is called out to distribute material for several jobs, so as to fill a complete working day. For some jobs, yard shifters do the work. Occasionally, material is delivered by local freight.

Long Island:—Space is usually so limited or trains so frequent that materials have to be unloaded as opportunity offers, as near as possible to the point of use. Cement and rods are bought for delivery at the company's storehouse and are distributed from there as required. Sand is obtained from a company pit as required and broken stone is bought by the scow load, both sand and stone being delivered direct to the site. When large operations are under way, some stone is stored to assure a supply in case of delay in the delivery of any consignment. Work trains are under the control of a director of work and spoil trains who is advised each day by the superintendent of construction what service is wanted the next day.

Missouri Pacific:—Material is unloaded from local freight trains wherever possible. Where too much delay will be caused, a special engine is assigned.

Michigan Central:—The work train service depends entirely on the location and magnitude of the work. Where it is possible, a regular switch engine handles the cars, but out on the line, a road train is employed. Where it is possible it is the endeavor to unload all material needed for the job at one time.

Nashville, Chattanooga & St. Louis:—A special work train is used wherever enough material is involved to justify; otherwise the work is usually performed by a local work train.

Norfolk & Western:—A side track is placed for storing and unloading construction material. Work train service is needed after this only in exceptional cases. Train crews handle them under orders from the dispatcher's office.

New York, Ontario & Western:—Where sidings are not available, enough material is accumulated for a day's work with a work train. A work train is then used for one day to unload all material.

Oregon-Washington Railway & Navigation:—Work trains are usually under the direction of the engineer in charge.

Pennsylvania:—Material for concrete work being done by the division forces is usually handled by the supervisor's work train. If done by contract, the contractor has to make all his arrangements for work train service to handle his material, in which case, if he needs additional service, other than merely placing the cars, he is required to rent such equipment as may be necessary. In practically every case, the finished product is put in place by company forces. If, however, this is done by contract, the contractor is required to rent such necessary engine service as he may desire from the company.

Pennsylvania Lines West:—The work train service required is charged to the cost of the superstructure or substructure of the bridge as the case may be, and to the appropriate operating expenses or road and equipment account. Service is usually furnished contractors without charge, under the contract.

Southern:—When work is done by company forces, the materials are usually unloaded from a local freight yard, and no work train is required.

Describe Methods for Concreting in Cold Weather and Protection Against Frost.

This is a question on which the southern roads have little to say, but with the roads of the northern states and Canada, the question is a live one. Wherever practicable, all concrete work is done during the warm months, but where the winter season is long, it becomes necessary to do considerable concreting in freezing weather.

The necessity for heating the ingredients in freezing weather and keeping the concrete warm after it is placed, is generally acknowledged. The methods for accomplishing this vary considerably. The different methods of heating the sand and stone are steam pipes, steam jets and fires in pipes or under grillages laid under piles of material. The protection of the concrete in place is secured either by housing it in and warming with stoves, steam coils, etc., or by covering it with double forms with air spaces, sacks, tarpaulins, hay or anything that will prevent the circulation of air in contact with the forms. Salt is used under certain restrictions in mass concrete, but, obviously, it can not be permitted in reinforced concrete on account of the action of salt on the reinforcing steel.

Santa Fe:—In general, no attempt is made to build reinforced concrete work during freezing weather. Where this is unavoidable, the work is enclosed with boards or canvas, and small portable stoves or a steam jet is used for keeping the concrete under the protection hot.

Baltimore & Ohio:—All materials are heated, and in severely cold weather salt is used in the proportion of 2 lbs. per cu. yd. of concrete. The work is then well covered.

Canadian Pacific (Lines East):—The materials are heated, and after being poured the concrete is protected from frost by tarpaulins or by a timber structure built over it, and heated by steam.

Chicago, Milwaukee & St. Paul:—During cold weather, arrangements are made to heat all materials. The sand and stone are usually kept thawed out by means of steam from an extra boiler. In some cases, the completed work is heated by means of salamanders and protected by canvas,—and in special cases, double forms are employed with air spaces or with cinder filling.

Chicago, St. Paul, Minneapolis & Omaha:—Where the temperature is 5 deg. above zero or lower, the stone, water and sand are required to be heated. The addition of salt to reinforced concrete is not allowed. All concrete deposited in freezing weather is protected by manure or tarpaulins until it has set. On some of the large river crossing piers, where floating cofferdams with grillage bottoms were sunk and partially filled with concrete while filled with water, steam pipes were introduced into the water within the cofferdam, which took the chill out of the water quite effectively. The surface of the unfinished work is cleaned off in all cases with a steam jet before beginning to place additional concrete.

Big Four:—Concrete placed in cold weather is protected against frost by using hot water and heating the stone and sand or gravel, by housing in and using stoves, or covering with manure, the first mentioned method being much more reliable.

Chicago & North Western:—Sand and stone are heated by piling them around a boiler shell or an old pipe of good size, in which a coal fire is kept burning. Water is kept hot by running a jet of steam into the tank with a hose, if there is a steam engine on the job. Where there is no steam available for heating, the water is conducted through heated coils of piping, the coils being simply a number of short straight lengths of pipe connected by U's. Salt is not used in any concrete work. Concrete is protected by stable manure piled around and over the forms.

Delaware, Lackawanna & Western:—The aggregate is kept free from frost by heating all materials. Concrete is protected in the forms by use of bags containing straw or live steam under canvas covering. No concreting is permitted in large arch spans or deck floors in freezing weather.

Duluth, Missabe & Northern:—Practically all of our concreting is done in cold weather. The sand, rock and water are heated, and after the concrete is placed in the moulds it is covered with hay and is kept warm with live steam for at least 48 hours.

Duluth, South Shore & Atlantic:—Protection is secured by heating the stone, sand and water; steam coils are also placed inside of and around the forms.

El Paso & South Western:—In the mild climate, special precautions against freezing are unnecessary, except on the Dawson line, where when necessary, new and exposed concrete is covered with concrete sacks and sand as required.

Grand Trunk Pacific:—Steam coils are placed between the housing and the forms. The aggregate and water are heated before mixing. No salt is used.

Great Northern:—The contractor is required to heat the sand, water and broken stone or gravel and to protect the concrete until it is sufficiently set, so that it will not be damaged by freezing. It is also specified that the material shall not be heated above 150 deg. F. The method of protecting the concrete until it is sufficiently set is left to the contractor, but is subject to the approval of the engineer in charge. This is usually done by placing tarpaulins around the concrete and heating it with salamanders. The use of salt to reduce the freezing point is permitted to a limited extent in mass concrete, but is not permitted in reinforced concrete.

Illinois Central:—No concrete is placed in a temperature of less than 25 deg. F., except in emergency cases. Sand and water are then heated with a steam jet. Where the concrete is thin as in slabs, columns and girders, tarpaulins and salamanders are used.

Kansas City Southern:—The sand and water are heated by coils of pipes, with hot water. The concrete is protected with sacks or fresh stable manure and wind breaks. Concrete is not placed in freezing weather where it can be avoided.

Lehigh Valley:—No concreting of slabs should be done in freezing weather. Where concreting is done in freezing weather, the water and sand are warmed, and the amount of water is reduced to a minimum. The finished work is protected by straw mats, etc.

Long Island:—Sand and stone are heated over cast iron pipes or on a rail grillage. The latter is quicker, as some of the smoke goes up through the stone. The concrete is covered with salt hay after being placed.

Missouri Pacific:—"Instructions for placing concrete during freezing weather." The placing of concrete during freezing weather shall preferably be avoided. When it is necessary or desirable to continue the work under such conditions, permission in writing must be obtained from the engineer. When it is necessary that concrete be placed during freezing weather all the materials shall be warmed and in addition salt shall be mixed with water in the proportion of 1 lb. of salt for each 18 gal. of water for each degree of temperature below 32 deg. Permission is granted under the following conditions:

No concrete shall be mixed or placed when the temperature of the air is less than 32 deg. except in the presence of railway company's inspector. No concrete whatever shall be mixed or placed when the temperature of the air is below zero.

When the temperature of the air is between zero and 32 deg. all materials shall be thoroughly warmed and the following precautions taken:—

For plain concrete salt shall be added to hot water in the proportion of 1 lb. of salt to each 18 gal. of water for each degree of temperature below 32 deg. In order to insure the use of the proper amount of salt the water shall be measured in barrels and the salt weighed. The amounts to be added at different temperatures to each barrel of water, the capacity of a barrel being assumed at 52 gal., are as follows:

Temp. of Air.	Lbs. Salt to Each Bbl. of 52 Gals.
32 deg.	0
30 "	6
28 "	12
26 "	18
24 "	24
22 "	30
20 "	36

No more than 36 lb. of salt to a barrel shall be added under any conditions. The salt shall be thoroughly dissolved in the water before the water is used. No salt shall be used in reinforced concrete.

The cement shall be kept from freezing by maintaining a fire in the cement house or car in which it is stored. Cement shall not be left in the open but shall be moved directly from the shelter to the mixer. The amount of cement shall be increased 1 per cent for each degree of temperature below 32 deg. as follows:

Temp. of Air.	Per Cent Increase In Amount of Cement:
32 deg.	0
28 "	4
24 "	8
20 "	12
16 "	16
12 "	20
8 "	24
4 "	28
0 "	32

Sand and broken stone shall be well heated, suggested methods being by placing them over a half cylinder of sheet steel under which a hot fire is maintained or on a platform on which a steam coil is kept hot. The hot sand or broken stone shall be moved directly from the heater to the mixer. The material shall be so protected at all times that frost can not reach them. Materials that have been frosted and from which an attempt has been made to remove the frost by washing or sprinkling with warm water will not be permitted in the work until it has been further heated as above suggested.

The heating of the material shall be so controlled that the mixed concrete emerging from the mixer shall have not less than the following temperatures:—

Temp. of Air.	Temp. of Mixed Concrete Not Less Than:
32 deg.	32 deg.
28 "	40 "
24 "	48 "
20 "	56 "
16 "	64 "
12 "	72 "
8 "	80 "
4 "	88 "
0 "	96 "

Form lumber shall be protected from the frost and shall be so housed as not to come in contact with snow or ice. After the forms are erected the interior shall be heated by a stove or steam pipes to remove all evidence of frost.

At night and at other times when the work is stopped the interior of the forms shall be kept warm so that the top surface of the concrete can not freeze. When concrete is finished the top surface shall be protected by a double layer of boards with heavy building paper between and covered with canvas.

Forms shall be permitted to remain on the piers longer than under other conditions, the length of time depending upon the average temperature of the air during the last few days of placing the concrete as follows:

Average Temp. of Air During Last Few Days of Placing Concrete:	Number of Days the Forms Must Remain Undisturbed After Placing the Last Concrete:
32 deg.	10
28 "	14
24 "	18
20 "	22
16 "	26
12 "	30
8 "	34
4 "	38
0 "	42

In reinforced concrete the metal shall be heated to the temperature specified for mixed concrete. Shovels, wheelbarrows, platforms, concrete mixers and other equipment used for handling concrete shall have the frost thoroughly removed by the application of warm water before proceeding with the work.

Michigan Central:—Where a large job is handled in cold weather, coils of steam pipe are attached to a large boiler. The stone and sand are unloaded over the coils and kept thoroughly heated in this way. Besides this, the water is heated. On smaller jobs the stone and sand are heated by running the end of a steam pipe into the pile and, of course, the water is heated. In very severe weather some salt is used in the water in unreinforced work. After depositing the concrete, it is covered up, and kept heated with salamanders, where it is possible, for 48 hours. Mass work is generally covered with canvas or straw, or both.

Nashville, Chattanooga & St. Louis:—On big jobs, lasting throughout the winter, sand and stone are heated by steam. Small jobs are protected by covering and building fires with old ties.

New York, Ontario & Western:—When the weather is severe, the water, sand and stone are heated by steam from a portable boiler. At night the work is covered with canvas and kept warm by means of steam pipes. A small amount of salt is used in the water, but only enough to give the water a slightly salty taste.

New York, New Haven & Hartford:—Materials are warmed before mixing. Finished surfaces are protected by straw and canvas, and, in the case of viaduct work, salamanders are kept lighted under the viaduct.

New York Central:—Extract from Specifications—"Concrete shall not be mixed nor placed when the temperature is below 32 deg. F., nor immediately subsequent to a period of freezing weather, unless special provisions are made to heat the ingredients. Surfaces which will be exposed upon completion shall be prevented from freezing until the concrete is well set and dry. Surfaces which will join other concrete work shall be kept from freezing until adjacent concrete is placed. Bridge seats, coping and all reinforced concrete shall be enclosed and a temperature of not less than 40 deg. F. maintained until the concrete has thoroughly set and all evidence of dampness of the surface has disappeared. The method used under these conditions shall first be approved by the engineer.

Salt or other injurious chemicals are not to be used in or on the concrete to prevent freezing, without specific instructions. Forms for such work shall be left in place at least three weeks, and shall under no circumstances be removed until the concrete is thoroughly set."

Norfolk & Western:—Reinforced concrete is not placed when the temperature is below freezing. Work is suspended early in the morning and late in the afternoon. Mass concrete is protected by canvas and the use of fires in salamanders.

Oregon-Washington R. R. & Nav.:—The work is usually arranged so as to avoid frosty seasons. Otherwise, to prevent freezing, the water or ingredients are heated and fires are built close to the work.

Pennsylvania:—The specifications do not allow concreting in cold (freezing) weather. This is necessarily, however, subject to some little variation and in real cold weather, the sand and stone are required to be heated and the concrete to be protected after being placed, by means of cement bags, straw or similar material.

Pennsylvania Lines West:—No concrete is made when the temperature is below 15 deg. F. When the temperature is between 15 deg. F. and 32 deg. F., all concrete materials are heated before mixing. This can best be done by running steam pipes through the piles of sand and stone and into the water placed in barrels, the steam being allowed to escape in the materials. Sand and stone are heated in such a manner as to drive out all the frost. The hotter the material, the less danger there will be of the concrete freezing, before it has time to set. When a finished concrete surface is made with a temperature of 32 deg. or below, or upon the completion of a day's work placing concrete during freezing weather, the exposed surface is covered with damp hay, straw, or manure, in order to protect it from freezing until it has time to set. The vertical face of the concrete is protected from freezing by packing the outside of the form with straw, or by placing a tarpaulin over the form and running steam line between the tarpaulins and the form.

Advise If It Is Your Practice to Make Test Cubes of the Concrete During the Progress of the Work.

The preparation of test pieces during the progress of the work has been recommended frequently. In order to show the condition of the concrete the test pieces must be exposed to the same conditions as the concrete from which they are taken. This test is not recommended as a means of determining the quality of the cement, or other ingredients in the concrete; this must be determined before they are mixed. It has been suggested as a means of determining whether the concrete has hardened sufficiently for the removal of the forms and has been done more frequently perhaps, in connection with building work, than on bridges.

It is evident from the reports of the roads, that the making of test pieces is not by any means general. The replies of 21 roads with a total mileage of 53,500, is "no." Eight roads, with a mileage of 46,500, advise that they make test pieces on certain work, or under special conditions of construction.

Santa Fe:—In general, on important jobs, or where there is uncertainty regarding the behavior of the sand, 6 in. test cubes or cylinders 6 in. in diameter and 12 in. long, are taken as the work progresses.

Canadian Pacific:—Not generally.

Chicago, Milwaukee & St. Paul:—On special work, sample cylinders are made for compression tests and subjected to weather conditions similar to the balance of the concrete, which is not subjected to load until these test pieces show satisfactory results.

Big Four:—Only on important jobs.

Missouri Pacific:—Not usually.

New York, New Haven & Hartford:—Yes, 6 in. cubes are tested by the engineer of tests.

Pennsylvania Lines West:—No, excepting where some trouble is experienced.

Southern:—On large and important work, it is the practice to make compression tests of concrete cylinders 6 in. in diameter and 16 in. long, as recommended by the joint committee.

Is Spouting of Concrete Permitted, and If So, Under What Restrictions As to the Slope of the Spout and the Distance Spouted?

The question regarding the spouting of concrete called forth a greater variety of answers than any of the other questions. Three roads reported that spouting is not permitted on their work under any conditions. Ten roads permit spouting without any specific restrictions as to slope or distance, but subject to the general requirement that the concrete shall be delivered in good condition at the forms. Sixteen roads permit spouting under specific restrictions as to slope, distance, amount of water, etc.

Evidently there is a great deal of dissatisfaction with, or distrust of, this practice. The rules and restrictions under which spouting is permitted on most of the roads reporting, indicate that the method will give satisfactory results, provided the work is properly conducted and carefully supervised. On those roads where it is prohibited, the belief evidently prevails that concrete can not be delivered in good condition by this method, or that the abuse of the method can not be wholly prevented by their inspection service.

The facility with which concrete can be delivered over a considerable range by spouting makes it desirable to permit the method, provided the work can be supervised so effectively that there will be no abuse of the method. That this is the most general view is shown by the number of roads, and the mileage represented by the roads permitting spouting under specific restrictions.

Spouting is not permitted on the Duluth, South Shore & Atlantic, and the New York, Ontario & Western and Grand Trunk Pacific.

Atlantic Coast Line:—In the slab yard the batch mixer is set on a standard flat car and the base of the slab forms is made level with the base of the rail. The concrete is spouted over this face. For field work, wheelbarrows are loaded at the mixer and wheeled to the forms.

Santa Fe:—Concrete has been spouted quite freely in building construction, but not on bridge work. When spouting was used no special restrictions were made except that the slope of the spout should be sufficient to force the concrete to flow very freely.

Baltimore & Ohio:—Spouting is permitted at angles of 40 to 50 deg., the distance depending on local conditions.

Canadian Pacific:—Spouting is permitted under the supervision of the engineer.

Chicago, St. Paul, Minneapolis & Omaha:—Spouting is permitted with no restrictions as to the angle of the spout or the distance spouted except that they shall, in no case, be such as to cause the separation of the cement, sand and stone. When concrete has to be deposited in water, trip bottom buckets are used to prevent the separation of the ingredients.

Central of Georgia:—Spouting is permitted. Requirements for the slope of the spout and the distance spouted are based on the non-separation of ingredients at the end of the chute with no fixed distances or slopes. Spouting methods in use by contractors have in general been satisfactory.

Big Four:—Spouting is permitted without any restrictions as to the slope of the spout or the distance spouted.

Chicago & Northwestern:—Spouting is permitted. No specific restrictions as to the slope of the spout or the distance spouted. Work must meet the general requirements that concrete shall be delivered to the forms in proper condition; also methods and procedure are subject to approval in a general way by the chief engineer.

Chicago, Milwaukee & St. Paul:—This method of placing concrete is used quite extensively on all classes of work. It is left to the discretion of the engineer in charge to see that proper systems of baffle plates are used to insure against the separation of the aggregate. 1: 1 slopes are frequently used in spouting when convenience demands it.

Delaware, Lackawanna & Western:—The spouting of concrete is not practiced to any extent, but is permitted where necessary in very short chutes. This road has not used high towers and long chutes.

Duluth, Missabe & Northern:—The spouting of concrete is allowed. The road does not specify any angle or distance, but inspects the condition of the concrete to see that too much water is not used.

Great Northern:—No restrictions are placed on the slope of the spout or the distance spouted, excepting only the general requirements of the specifications, that methods and equipment are subject to the approval of the chief engineer.

Illinois Central:—Spouting is done very rarely, and is avoided as much as possible.

Lehigh Valley:—This road has had very little experience in spouting concrete. If this method is employed, the dropping of the mixture should be avoided on account of the segregation of the aggregates.

Long Island:—Spouting is permitted reluctantly. The difficulty is to keep the contractor from using an excess amount of water. The inspector requires a consistency which will not allow the ingredients to separate in the spouts.

Louisville & Nashville:—Spouting is permitted, without limit as to slope and distance, except that segregation must be prevented.

Michigan Central:—The spouting of concrete is permitted, keeping the slope and the distance such that the separation of the coarse and fine aggregates is held within safe limits. There have been very few cases where it has been necessary to spout more than 50 ft.

Nashville, Chattanooga & St. Louis:—Spouting is allowed where conditions permit, the slope of the spout being fixed so that the material will slide as a whole, and not roll. No restriction is placed on the distance spouted.

New York, New Haven & Hartford:—Spouting is permitted, but the slope and distance spouted must be such that there will be no objectionable separation of the stone from the sand and cement.

New York Central:—Spouting is permitted with metal spouts at a slope steep enough to insure the concrete flowing freely without adding water. This makes it impracticable to spout concrete very far.

Oregon-Washington R. R. & Nav.:—Spouting is permitted. No special restrictions, but concrete must be delivered in good condition and properly placed.

Pennsylvania:—The spouting of concrete is permitted with such slopes that the concrete material will slide and not roll. No fixed limit is set for the distance material may be spouted, provided that, with other conditions, the work is done satisfactorily.

Pennsylvania Lines West:—The spouting of concrete is permitted, the distance spouted being not greater than 100 ft. on a 1: 1 slope.

Seaboard Air Line:—No restrictions are placed except that the rock must not be separated from the cement when deposited.

Western Pacific:—Spouting has been given up almost entirely, but the use of a spout is permitted where concrete is dropped almost vertically, and where it can be examined and reworked.

Southern:—Spouting is permitted, subject to the condition that the results shall be satisfactory.

What Precautions Are Taken to Insure Thorough Mixing?

This question did not bring out the information desired in all cases. In most cases the replies failed to give the means devised or the methods and procedure adopted to get the results. " Rigid inspection or supervision by competent foreman," is the reply from more than half of the roads reporting on this question. The belief is apparently quite general that if the mixture is left in the mixer long enough, no other precaution is necessary to secure good mixing. The inspector or supervising foreman is left largely to his own devices on hand mixing.

If he is an experienced and competent man he will get the desired results, but there will undoubtedly be many variations in the methods adopted by different men to obtain the same results.

Machine mixing is generally required on all work of sufficient magnitude to justify a mixer, and batch mixers are quite generally specified. Continuous mixers are apparently not in good standing among the engineers who write the specifications and prescribe the methods. When hand mixing is done, the manner of mixing is sometimes specified in detail, requiring the sand and cement to be mixed dry, then the stone added with some water and the mass shoveled until all of it has been turned a specified number of times, water being added during the mixing until the required consistency is obtained.

Atlantic Coast Line:—The mixing is left to the concrete foreman on company work, who acts under the direction of the engineer in charge. The engineer visits the work done once each week to see that good work is being done. Where contract work is being done, an inspector is kept with the gang all the time.

Santa Fe:—Where work is handled by company forces, it is generally insisted that the mixer be run longer than would be actually required to incorporate the ingredients of the concrete uniformly. For contract work it is generally insisted that the mixer be run long enough to insure a thorough incorporation of the parts.

Chicago, St. Paul, Minneapolis & Omaha:—The details of mixing concrete by hand are as follows: The proper amount of sand is measured and spread out on the platform and the proper amount of cement is spread upon the sand. The sand and cement are then turned with shovels or hoes until evenly mixed. The proper amount of stone having been previously drenched with water, if considered necessary, is evenly spread upon the mixture and carefully wet with water, which must not be dashed on. The materials are then turned at least three times, sufficient water being added during the turning to produce the proper consistency, which is considered to be what is known as "medium wet" and which does not require ramming when put in place.

We require machine-mixed concrete to be of the same consistency as the hand-mixed. A batch mixer is required—the continuous type being barred—and a systematic method of delivering the ingredients to the mixer is insisted upon to insure proper proportions.

Central of Georgia:—Concrete is inspected by the engineer. Hand mixed concrete is turned three times after the stone is added. Machine mixed concrete is given a fixed number of turns after trial by an engineer.

Chicago, Milwaukee & St. Paul:—Practically all of the concrete is machine-mixed. An approved type of mixer, preferably of the batch form, is employed. The size of the batch is not allowed to exceed the rated capacity of the machine and the number of revolutions of the mixer for the discharge of a batch must be sufficient to secure homogeneous concrete that is uniform in color.

Big Four:—The precautions taken to secure thorough mixing are by inspection and specification. The specifications provide in detail for the size of the batch and the manner of mixing in hand mixing, and for machine mixing "the machine shall be of the batch type such that a precise and regular proportioning of materials may be controlled and that the product delivered be of the required consistency and thoroughly mixed."

Chicago & Northwestern:—Hand mixed concrete is made in batches not exceeding 1 cu. yd. The sand and cement are mixed first in the proper proportions. The stone, previously wetted, is added, and water is added slowly during the mixing until the mixture is of the required consistency. The concrete shall be of a consistency that will not require ramming when it is placed.

Batch mixers are not specified, but it is required that provisions for the correct proportioning of the ingredients be made, such that the inspector can keep an accurate check on them. Machine mixed concrete must be of the same consistency as that specified for hand mixed.

Delaware, Lackawanna & Western:—All concrete is mixed by machinery. On large construction requiring continuous mixing, an inspector is kept at the mixing plant to insure proper mixing. Hoppers are placed over the mixer, which automatically measure the ingredients. Where hoppers are not used, the materials are placed accessible to the mixer, so that no time is wasted in placing a batch in it.

Duluth, So. Shore & Atlantic:—The time of the mixer is fixed according to the judgment of the engineer in charge.

El Paso & South Western:—The ingredients receive a liberal turning in a concrete mixer.

Great Northern:—All concrete work is subject to inspection; and specifications require that the product as delivered shall be thoroughly mixed so that all the stone or gravel is covered with mortar.

Lehigh Valley:—The number of turns required for good mixing with a certain type of machine is determined, and then followed. Continuous mixers are not used.

Long Island:—It is the practice to time the mixing, making the mixer work a definite period before discharging the batch.

Louisville & Nashville:—Concrete is made a sufficient length of time in an approved mixer and subjected to thorough inspection.

Michigan Central:—It is the rule to depend on the foreman to watch the mixing of the concrete. Where work is done by contract, inspector looks after this.

New York, New Haven & Hartford:—After an examination of the mixing plant, the engineer prescribes the length of time that each batch shall be in the mixer.

Norfolk & Western:—Standard revolving batch mixers are used and each batch is mixed until a uniform color is produced throughout the mass.

New York Central:—The following is an extract from the current specifications: "Concrete may be either hand or machine mixed. A thorough mixture of the ingredients must be secured in which each pebble or stone is completely covered with mortar and the mass is of uniform color and consistency.

When concrete is mixed by hand it shall be done in the following manner:

The specified amount of sand shall be spread on a water tight platform and the specified amount of cement spread upon the sand. The sand and cement shall be turned dry with shovels or hoes at least four times, and until thoroughly mixed. Sufficient water shall then be added to make a thin mortar which shall be spread in a uniform layer upon the platform. The specified amount of broken stone or gravel, which shall be wet, shall be spread in a uniform layer upon the mortar and the whole mass turned at least six times.

When concrete is mixed by machine, a batch mixer shall be used, so constructed and operated as to insure the proper proportioning and complete mixing of materials. The materials shall be mixed dry before water is added. Approval of the type of mixer shall be secured before work is commenced.

The number of turns required before and after water is added to secure the proper consistency shall be determined by trial and shall be the minimum number of turns allowed before discharging. Each batch shall be discharged entirely at one time. Before the mixer is put in operation, and on stopping work at any time it shall be thoroughly cleaned out."

Pennsylvania:—Thorough mixing is secured by using machines for mixing the concrete wherever this is practicable. If the use of machines is not practicable, thorough mixing is insured by having all the material mixed under the supervision of a competent inspector.

Seaboard Air Line:—All mixing is done under the direction of a special mixer inspector, who is stationed at the mixer all the time mixing is going on.

What Measures, if Any, Are Taken to Minimize the Amount of Air in the Mixture or to Expel It After the Mixture is Deposited?

There is a surprising uniformity in the replies to this question. No efforts are made to minimize the amount of air in the mixed batch; and after depositing the batch the air is expelled by tamping, spading or working with slicing tools.

It was not expected that the answers to this question would reveal any decided progress, so far as common practice is concerned. Whatever discussion there may have been regarding the weakness of concrete due to entrained air, it has not resulted in the development of any method more effective than working the material thoroughly with ordinary tools, after it has been deposited.

During the early months of 1915, there appeared in the Engineering Record a very able discussion on the study of concrete through the application of the microscope by Nathan C. Johnson, of the Raymond Concrete Pile Company. In these articles the author placed special emphasis on the importance of expelling the air in the mixture, to prevent the formation of voids in the finished concrete. Among the items in the summary of the first paper were the following: "That the cement matrix is not worked at its maximum efficiency, largely because of air and water voids in the mass," also, "that the planes of failure in a crushed concrete run from air void to air void, confirming previous reasoning in regard to the weakening effects of such voids," and "that the prevalence of air voids . . . is greater at the surface of contact with the large aggregate than in other portions of the matrix."

The voids in concrete due almost wholly to the presence of air or excess water in the mixture, reduce the strength of the concrete by simply reducing the effective section. About the best that we can do is to guard against too much water in the mixer, and after it has been deposited for men in rubber boots, to work with spades, rods and tamping irons to bring the air and water to the surface.

Chicago, Milwaukee & St. Paul:—No special precautions are taken, except to avoid excessively wet mixtures and to secure careful puddling of the mass after it is in place.

Delaware, Lackawanna & Western:—Concrete is deposited in a pile and is spread and rammed by workmen treading in mixture.

Great Northern:—No measures are taken to minimize or expel the air, except that the concrete mixture is required to be of such consistency that when dumped in place it will not require much tamping.

Illinois Central:—Concrete falling more than 3 or 4 ft. after leaving cars, wheelbarrows or chutes should be avoided as much as possible. Chutes should have outlets that will give the concrete a vertical drop. Concrete in small bodies, such as columns, girders or slabs should be thoroughly puddled, and in large bodies it should be placed in complete batches as a unit, or if moved from a mixing board it should be kept in one mass and moved by shoving with the foot or a shovel and not cast. Care should be taken to keep the mortar and stone together.

New York, Ontario & Western:—Men with rubber boots work in the forms and the concrete is well spaded.

Norfolk & Western:—Too much water is not permitted to be used in mixing. The consistency is such that concrete will flow under light pressure but will not cause any separation of the ingredients.

New York Central:—Concrete is spaded or churned with stone forks.

Pennsylvania:—No particular measures are used to minimize or expel the air from the mixture after it is deposited, other than to mix the concrete wet and to insist on careful spading.

Southern:—No difficulty has been experienced from voids in concrete that has been properly tamped, except in some cases where the forms have leaked. The only way to take care of this feature is by proper inspection.

Advise If the Cement Gun (Using Compressed Air) or the Atomizer, (Using Steam) Has Been Used in Construction or Maintenance. If So Have the Results Been Satisfactory?

These appliances for placing concrete have been developed within the last few years. They are not intended for use in placing concrete where the ordinary equipment will serve, and where concrete of the usual quality is wanted. The duty required of them is to place the material where it is not practicable to deposit it in forms, and to give a dense and impervious product. The deposited mixture is mortar. The cement gun uses no stone. The atomizer uses stone up to ¾ in. in the mixture, but the stone rebounds from the surface to which it is applied. Its only function is, apparently, to pack and tamp the mortar against the surface to which it is applied.

These machines can be used to good advantage when applied to the kinds of work to which they are adapted. It is not necessary here to mention the kinds of work they can do, as all concrete builders are familiar with the claims made for them. It appears from the reports received, however, that these appliances are in use on only a very few roads, and the engineers in charge of concrete construction can not speak from personal experience. Twenty-six roads report not having used either kind, but the roads which have used them nearly all report satisfactory results. One road reports that in one instance at least, the results were unsatisfactory. The kind of work or the nature of the defect was not stated.

The following roads report having used either the cement gun or the atomizer, or both: C. M. & St. P., B. & O., C. B. & Q., D. L. & W., C. R. I. & P., N. C. & St. L., N. Y. C., P. R. R., P. L. W. and L. & N.

How Is the Proper Time for Removing Forms Determined Under Varying Conditions?

It appears to be the common practice to leave it to the engineer in charge to determine the time when forms can be removed safely, without handicapping him with detailed instructions. The weather conditions and the kind of structure enter largely into the considerations. A few roads report tests, such as breaking off exposed portions of the work, or using test pieces that are made at the same time and exposed to the same conditions as the work.

From the replies received, a man not already familiar with concrete construction would hardly be able to decide on the time for removing the forms. There is a wide range in the time allowed for setting, even under the same weather conditions. This may be accounted for by assuming that structures of entirely different character were in mind when the different replies were written.

A general review leads to the conclusion that in summer weather, mass concrete, such as retaining walls, abutments and piers, should have two to three days, and a little more if the structure is high or massive. When weather is cold, but not freezing, the time should be from one to two weeks. Forms for slabs, arches and culverts should remain in place in warm weather, from one to two weeks, and the structure should not be loaded for 30 days. In cold weather, the time should be correspondingly longer.

Atlantic Coast Line:—The climate along this line is such that there is but little variation in the set of the concrete. The forms are left on slabs and like construction 2 to 3 weeks, and on pedestals, 1 to 2 weeks.

Canadian Pacific:—This is left to the judgment of the engineer and is generally 7 days for slabs, with a longer period in cold weather.

Chicago, St. Paul, Minneapolis & Omaha:—This is determined by exposing a small portion of the work sufficiently to make an inspection of it. Forty-eight hours is the minimum under the most favorable conditions with about one week as the average length of time during the summer. In the winter, forms are left on much longer, depending on conditions.

Chicago, Milwaukee & St. Paul:—The time for the removal of the forms is dependent entirely on the season of the year when the work is done, and is done only as the engineer in charge may authorize. On work built during the winter, forms are frequently left until spring before they are removed.

Big Four:—The proper time for removing forms is determined by the temperature and conditions of load and also partly by the necessity for doing work on the finished surface.

Chicago, Rock Island & Pacific:—The forms must not be removed within 36 hours after concrete has been placed, nor until it is thoroughly hardened.

Delaware, Lackawanna & Western:—Forms supporting flat slabs are removed 14 to 28 days after the concrete has been deposited, depending upon the size of the slabs and the season of the year. Centers under arches are not struck in less than 28 days, except in case of small spans.

El Paso & South Western:—The forms are usually removed at the end of 7 days. Concrete is not loaded under 28 days.

Great Northern:—Under ordinary conditions, it is required that forms must not be removed in less than 36 hours. This is considered sufficient time, except in cold weather and except for overhead structures exposed to locomotive blasts, and for structures, such as arches, where the removal of the forms would subject the concrete to strains.

Illinois Central:—Slabs, girders and other concrete in spans, when built in place, should have the supporting forms left in place two to four weeks, according to the length of span and the temperature. When slabs are made in the yard, they should not be lifted until 30 days old or put under load inside of 60 days. Side forms of small work may be removed within 24 to 72 hours, according to their height and thickness and during cold weather in from 3 to 10 days. Forms for heavy piers and abutments may be removed after 36 to 72 hours, according to height and during cold weather in from 4 to 10 days.

Kansas City Southern:—Forms are usually removed in 2 to 3 days. Protruding knobs or seams are knocked off and conditions noted.

Lehigh Valley:—The season of the year, the general weather conditions, the setting of cement ascertained from tests, and more particularly the character and duty of the work.

Long Island:—Ordinarily forms for retaining walls are left in place for at least a day or two in summer, and a week or more in winter. When the surface is to be treated, the forms are usually removed the day after the concrete is poured, or as soon as the surface indicates that setting is progressing well.

Forms for fences are removed within a day, to permit using them over again and also to facilitate surface treating before the concrete hardens too much.

Forms for bridge decks are usually left in place from 2 or 3 days to a week. If special they are not removed inside of a week, but if regular, and to be used over, they are removed in a few days in summer and in a week or more in winter.

Louisville & Nashville:—Forms are removed upon instructions from the chief engineer's office.

Michigan Central:—When forms can not be left until such time as one is absolutely sure that the concrete is set properly, it is tested before removing the forms.

New York, Ontario & Western:—The removal of the forms depends upon weather conditions; in warm weather mass concrete is allowed to set 48 hours or more; and reinforced concrete not less than 5 to 7 days before the forms are removed.

New York, New Haven & Hartford:—This road desires to keep the forms on for 10 to 14 days after pouring. If, however, the work is of a character demanding a fine finish, the forms are removed in 48 hours or sooner, so as to rub the surface before it has taken a hard set.

Norfolk & Western:—The proper time for the removal of the forms is determined by the sound produced by striking the concrete with a hammer in conjunction with the character of the work, as to whether self-supporting or not; also the time of setting and the temperature of the atmosphere are considered.

Pennsylvania:—The time for removing forms varies considerably with the temperature at which the concrete is poured, the general conditions under which the work is done and also the work which the concrete is to perform. If concrete is not subject to any other stress than direct compression, the forms are removed somewhat sooner, of course, than where the concrete is subject to bending or tension stresses. This is a matter which must, of necessity, be left to the judgment of the engineer in charge of the work.

Pennsylvania Lines West:—The proper time for the removal of forms is determined by experience. If the surface is to be finished smooth by rubbing, forms are removed as soon as the concrete is set and, when possible, in 2 days.

Give Any Other Information Which Would Be of Use to the Committee, And to the Association in Connection with Reinforced Concrete Bridges, With Particular Reference to Field and Construction Methods.

Canadian Pacific: (P. B. Motley, Engineer of Bridges.)—In designing concrete bridges, it appears that sufficient attention is not given to avoiding sudden changes in section. A reinforced concrete bridge is in reality a casting, and should be considered in the same manner as is customary for well-designed iron and other castings, with special consideration given to changes of section, where generous fillets and extra reinforcement should always be provided.

Big Four: (O. E. Selby, Principal Assistant Engineer.)—There are several features in our specifications which we think important in securing good concrete: First,—the careful inspection and proportioning of the sand and gravel, for concrete of uniform strength can not be secured with varying proportions of sand; Second,—If fresh concrete is to be placed on concrete which is already set, the surface shall be cleaned by picks or chisels until the stone is exposed. This involves some care and labor, but is the only way to secure satisfactory bond. Third,—The washing of the surface with cement grout or rubbing with floats or bricks is prohibited. We have found that after long exposure the surface which is left in its natural condition looks better than one which has been rubbed or washed. These features apply, of course, to all concrete work and not particularly to reinforced work.

Delaware, Lackawanna & Western: (A. B. Cohen, Concrete Engineer.)—In all our concrete work, much attention is given to construction joints. Retaining walls are built in sections 20 ft. to 30 ft. long; each section is built in continuous operation from footing course to underside of coping, thus avoiding all horizontal joints made unsightly by efflorescence, formed by water percolating through these joints and aggravated where the laitance is not removed from the surface of the lower layer before the next layer is poured. The surfaces of horizontal joints are sloped down from the face of the forms.

Where construction joints are necessary in piers and abutments containing large quantities of concrete, they are hidden by V mouldings tacked to the back of the forms. The laitance or soft film of neat cement formed on the surface is removed before the next layer is deposited.

Lehigh Valley: (F. E. Schall, Bridge Engineer.)—The general practice in vogue for mixing concrete is to use too much water, which is done to reduce the cost of labor. The excessive use of water is injurious to the cement. In early spring and late fall, or whenever cold weather may be expected, the excessive use of water should be guarded against. Proper aggregates, thorough mixing, either by hand or machine, careful depositing, packing and spading, and the use of smooth, substantial forms, are the main requirements for insuring good concrete.

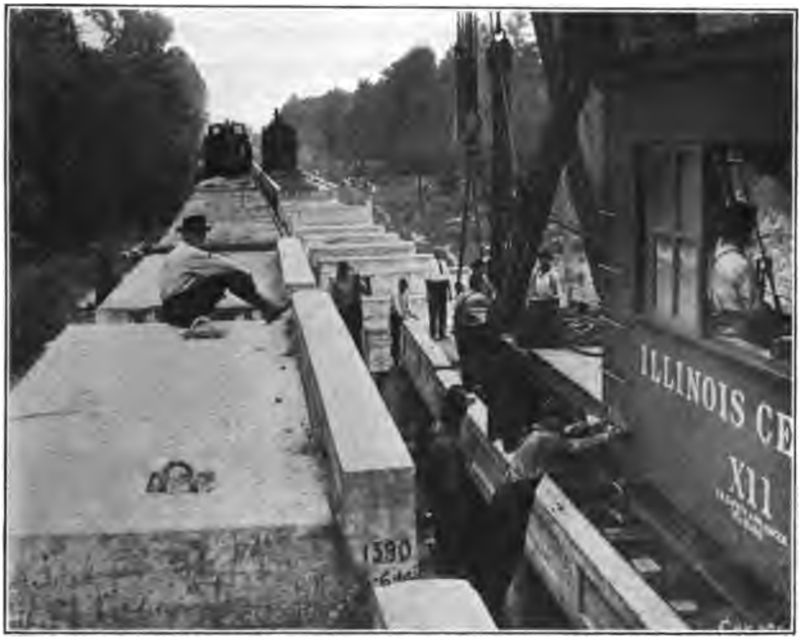
Long Island: (F. Auryansen, Bridge Engineer.)—All of our bridge floors now under construction are being waterproofed. Up to 1912, highway bridges were not so treated, reliance being placed on the pavement to shed water, but it is not thoroughly or uniformly satisfactory, even sheet asphalt leaking quite badly, so that we now protect these slabs as carefully as we do the track bridges. The main reason for keeping the concrete dry is to prevent electrolysis; in our own electric zone, and for all trolley cars, direct current is used, and we do not care to take any chances on the permanency of our bridges.

The best waterproofing can be done in hot weather, when the concrete is warm and dry. The surface to be waterproofed has to be well smoothed in order to save pitch as well as to get a better job of waterproofing.

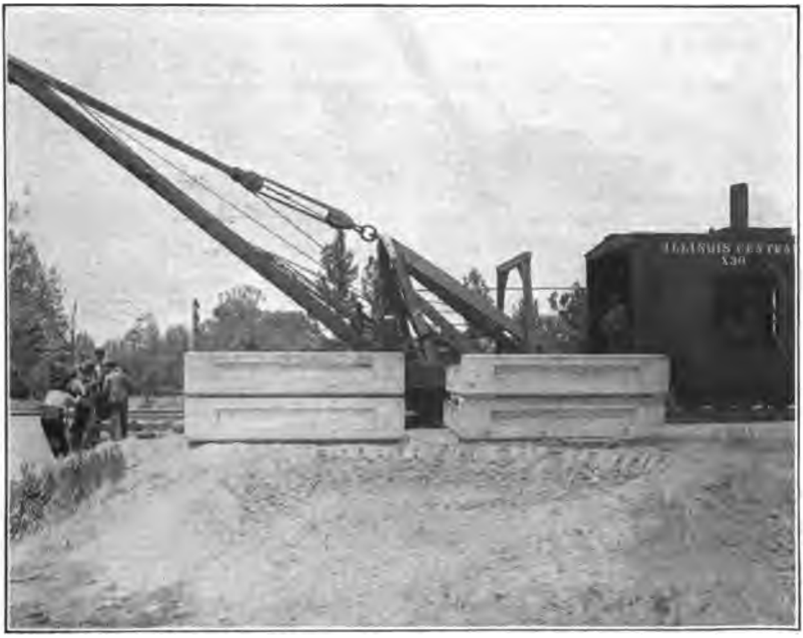
Pennsylvania Lines West: (J. C. Bland, Engineer of Bridges.)—Girder type, reinforced concrete highway bridges, with a roadway of 20 ft. and a total width of 30 ft. and a total length of 118 ft., with 6 supporting bents each of two reinforced concrete posts, all constructed as a monolith with no provision for expansion, are in perfect condition, and without cracks, after 4 years.

Elgin, Joliet & Eastern Ry.: (A. Montzheimer, Chief Engineer.)—Stone culverts on our line consist of stone abutments with stone top slab reinforced with 60-lb. or 65-lb. rails. In making these changes under traffic we put in falsework to carry the traffic while the tops of the culverts are being removed. We then build the forms, place the reinforcement, which consists mostly of ¾-in. square twisted reinforcing rods. Then we set up the concrete mixer at a suitable point where the concrete can be spouted from the mixer to the form. After the concrete is run and thoroughly dried out, the culvert tops are waterproofed with built-up waterproofing and the top covered with torpedo sand. We then allow the concrete to set for approximately 30 days before any load is put on. It is then backfilled, the temporary work taken out and traffic put on.

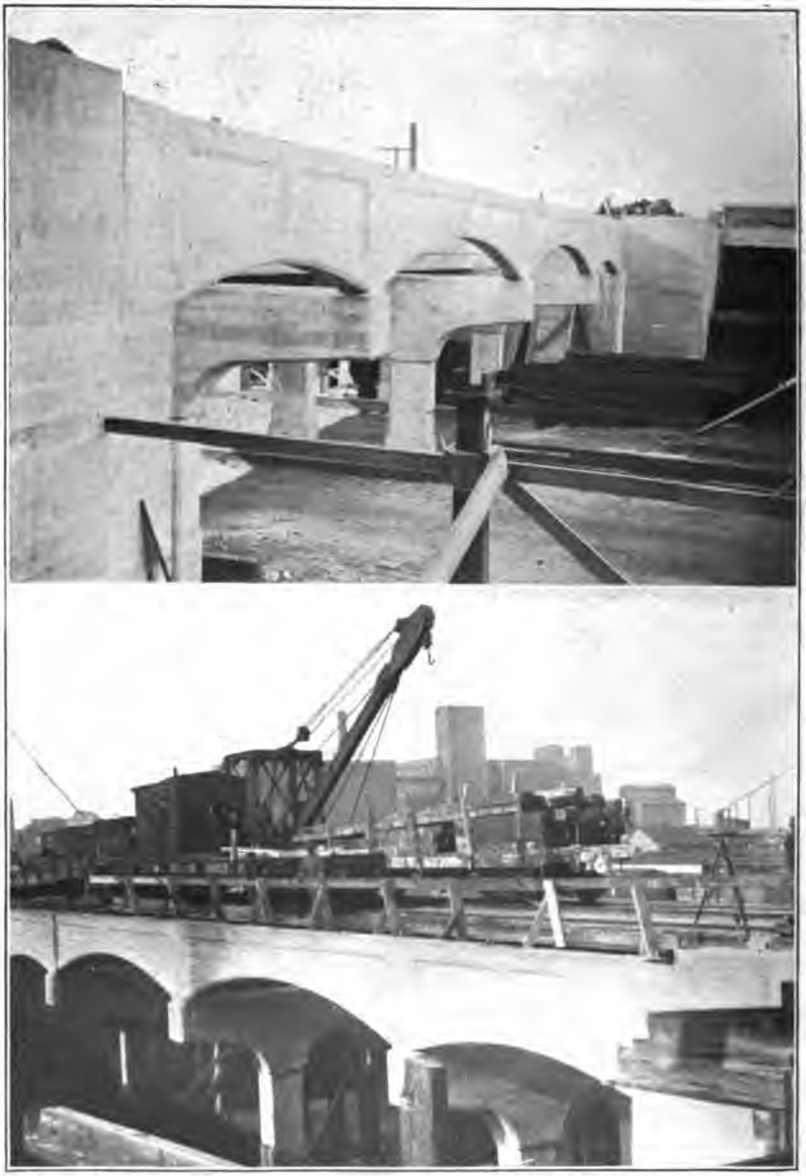
O. F. Dalstrom,
A. Montzheimer,
I. L. Simmons,
J. A. Bohland,
C. J. Scribner,
D. C. Zook,
T. J. Stuart,
Committee.



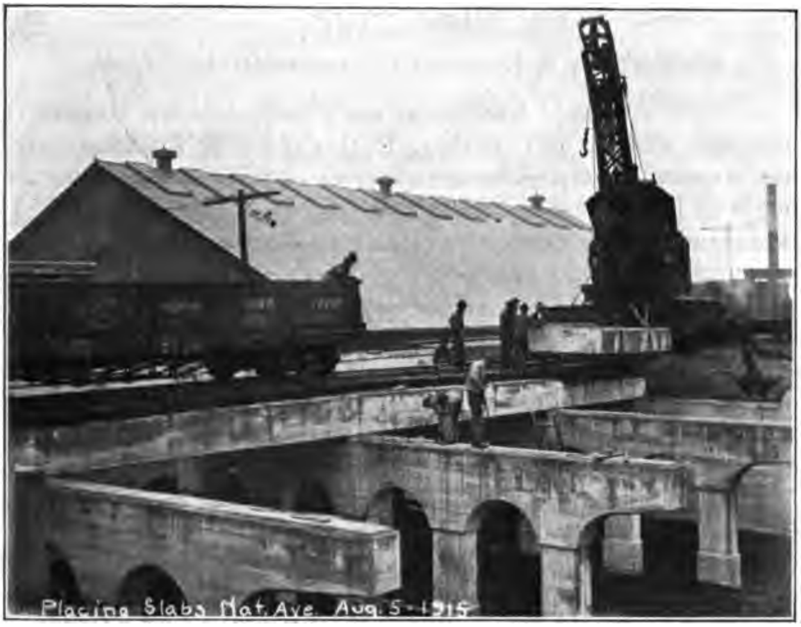
Placing Slabs on Double Track, Illinois Central R. R.



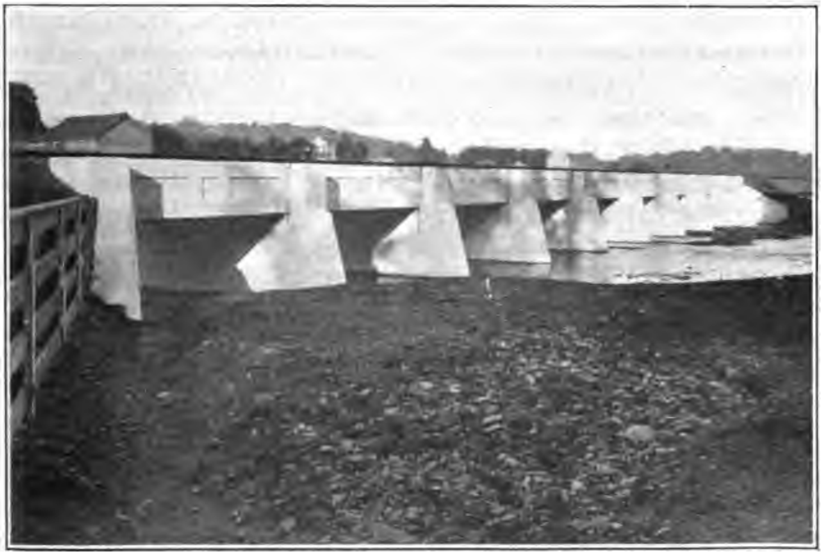
Placing Slabs on Single Track, Illinois Central R. R.



Portal, National Ave. Subway,
C. & N. W. Track Elevation, Milwaukee.



Placing Concrete Slabs, National Ave. Subway, C. & N. W. Track Elevation, Milwaukee.



Concrete Bridge, Buffalo, Rochester & Pittsburgh Ry.

DISCUSSION.

(Subject No. 8, Reinforced Concrete Bridge Work.)

The President:—Are any of the members of the committee here that wish to add anything to this report? The committee has prepared a very elaborate synopsis of present practice. We ought to hear something from some of our members on this. If there is no further discussion on this subject, before we go to the next paper, I would like to say that I think perhaps in judging of some of the replies received to the committee's questions, it should be borne in mind that these questions are very general and the man receiving these questions would judge them entirely by the work which he was handling or which came under his supervision, and I think that will oft-times explain some of the discrepancies in practice disclosed in the reports.

E. E. R. Tratman:—In discussing the use of compressed air for placing concrete the report refers only to the cement gun, which deposits mortar and not concrete. Mention should be made, however, of the McMichael system of placing ordinary concrete by compressed air. This system has been used extensively for placing the lining of tunnels and building concrete bridges. In other words it is a process for construction work, while the cement-gun system is mainly for repair work or protection purposes. As to the methods taken to insure proper mixing of concrete it seems to me that this is a matter which should be given more serious attention. In many cases there is little check upon the time of mixing, as the inspector is more often watching the placing of the concrete than watching the mixer crew. If there is a little delay in getting material to the mixer, the batches may be run through rather quickly so as to start pouring again without much delay, and in very many cases the mixer man practically runs this part of the work to suit himself.

The President:—We have with us Mr. Harold P. Brown of New York City, who will give us a short paper on the use of the concrete atomizer, a machine which is in successful practice at the present time. This properly comes under the head of the subject now before us. The subject of the paper is "Steam Jetted Concrete."

STEAM JETTED CONCRETE.

(By Harold P. Brown.)

During the past two years a new method of mixing, treating and applying concrete has been developed which has been tested on the Delaware, Lackawanna & Western railroad, the Chicago Great Western railroad and the New York Central. This method consists in mixing measured amounts of cement, sand, stone and water in a cylinder which is placed under 80 lbs. steam pressure during mixing with about 50 deg. of superheat. The heat serves to open the pores of the materials and to prevent any condensation of the steam during mixing, while the pressure drives the water into each portion of the mixture and serves to prevent evaporation of the water in the concrete.

A self-clearing outlet valve leading to a wire-wound rubber hose 1¾ in. inside diameter is then opened and the concrete is carried by a jet of steam several hundred feet and deposited on the work with a force due to a nozzle pressure of about 45 lbs. to the square inch. The force of the blow causes the concrete to adhere firmly to the surface which it strikes. This may be either a wooden or metal form, a brick, stone or concrete wall, or a sand or earth embankment. The high degree of heat and the release of pressure cause the concrete to set quickly, and a depth of 15 in. has been shot on to a vertical wall at one operation. The resulting concrete weighs about 171 lbs. to the cubic foot while the same materials hand tamped weigh about 137 lbs. The tensile and crushing strength are practically the same as that of granite, and the structure is so close that the surface will take a handsome polish, or it may be tooled. A thin layer of crushed marble can be placed on old walls so firmly as to take a fine finish.

The machine which produces this high quality of concrete is called the concrete atomizer, and although it can be operated with compressed air it gives far better results with steam at a less cost. When steam is used the only apparatus necessary beside the atomizer is a boiler operated at about 90 lbs. pressure with its supply pipe carried back and forth in the stack or bonnet to obtain about 50 deg. of superheat. This apparatus is very convenient for railway repair work along the right of way, using steam from a locomotive with a pressure reducing valve set to 90 lbs. The drop of pressure gives sufficient superheat for the purpose. Old frame structures can be fireproofed and given a handsome appearance by a ¾-in. layer of concrete, or new buildings with hollow concrete walls can be rapidly and cheaply erected. Structural steel can be covered with a thin fire-proof coating.

In the summer and fall of 1914 the Delaware, Lackawanna & Western equipped a train with this apparatus and repaired concrete retaining walls, etc., in Newark, N. J. This company also used the same apparatus with compressed air to repair the piers, beams and girders of its Hoboken terminal where poured concrete had been honeycombed and disintegrated by tide water and sewage discharged under the company's piers.

Fig. 1 shows the concrete atomizer used on the Lackawanna railroad which will handle about 10 cu. ft. of loose material, convey it several hundred feet through pipe or hose and apply it on the work when operated with a 20 h. p. boiler. A batch can be mixed, treated and applied in from 4 to 6 minutes. To do the same work with compressed air requires a 60 h. p. boiler, 50 h. p. motor and compressor, a large receiver, an automatic pressure regulator and a water pump and circulation system. A larger size of atomizer is made which will handle about 20 cubic feet of loose material and to mix, cure and place one batch requires between 4 and 6 minutes.

Fig. 2 shows the machine at work operated with steam from a locomotive on the Lackawanna railroad in Newark, N. J. This shows that very little material drops away from the work. Of course when the stream of concrete first strikes a wall nothing adheres but the cement. As soon as a thin layer of neat cement is deposited the sand and cement stick; and when this layer is from ¼ in. to ½ in. thick the pebbles also stick. But meanwhile the pebbles which rebound have delivered their blow to the mortar and forced it into all the little crevices and holes, making a thoroughly tight joint. The wasted pebbles and sand can be used again.

Fig. 3 shows the interior of a masonry-lined water conduit on the Lackawanna, at Rupert, Pa., from which all of the mortar had worn away, leaving holes and crevices through which the water escaped.

Fig. 4 shows the same conduit after lining with steam-jetted concrete. The conduit was but 5 ft. high and each section was about 150 ft. long. No difficulty was experienced, however, from steam and the work was lighted with only two kerosene torches.

Fig. 5 shows the use of steam for facing with concrete the United States Government levees on the Mississippi river below New Orleans. The embankment has a 2 to 1 slope and the concrete slabs are 25 ft. long and 3 in. thick. The hot concrete is carried through several hundred feet of hose.

A more extended piece of work has just been completed by the Chicago Great Western in their tunnel at Winston, Ill. This is a single-track, brick-lined tunnel about 2,600 ft. long on a 1 per cent grade. Here the locomotive exhaust had destroyed the lower layer of the brick arch and in many places part of the second layer. The tunnel was very wet. Analysis showed that the water was extraordinarily pure, but wherever the water and the exhaust blast had encountered the brick it had laminated in strata parallel with one face of the brick, sometimes the base, sometimes the side and sometimes the end. These layers were about 1-16 in. thick and were filled with a black gummy substance. The concrete at the portals and the mortar between the bricks were practically uninjured.

A train consisting of a locomotive, two flat cars and one box car was fitted up and steam at 90 lbs. pressure was taken through a reducing valve from the locomotive. The locomotive had two Westinghouse air compressors and its tank was fitted up with a turbine engine driving a dynamo for lights and a steam pump for wash water; also a steam signal whistle which could be sounded from any part of the train. The first flat car carried the cement, sand and gravel with the concrete atomizer placed close to the locomotive. A mixture of 1: 3: 2 was used, the gravel being what would pass through ½ in. mesh. One man operated the atomizer and two laborers delivered the materials.

On the second flat car was mounted a nozzle car running on rails 20 ft. long parallel with the track. This was equipped with a reversible steam engine which swung the nozzle back and forth on an arc whose center was the center of the arch of the roof. The nozzle car was advanced by means of a windlass and rope so that from one spotting of the train, a length of 10 ft. of the roof or sides could be covered with concrete. Incandescent lamps and two large acetylene torches were used to give general illumination.

Fig. 6 shows the nozzle car in operation. For several hundred feet at the east end of the tunnel, water poured through the roof at such a rate that it was thought impossible to make concrete adhere to the bricks. It was intended to first drill weep holes through the brick so as to drain the water away. When the work was started it was found that the pneumatic drills were not long enough to penetrate the brick arch. Rather than discontinue the work until longer drills could be obtained, the concrete was mixed at 80 lbs. pressure and shot up against the brick roof through which water was streaming down. The pebbles hammered the concrete into all the interstices between the brick and practically stopped the water with the first layer.

It was planned to machine trowel the last layer of concrete, mounting the sweeps or wipers on the frame shown on the nozzle car. This worked very well where the track was in the center of the tunnel, but elsewhere could not be used. After the final coat of concrete was applied a column of high pressure steam was jetted from the nozzle on to the work and this smoothed out the surface and gave it a troweled effect.

The President:—We are very much indebted to Mr. Brown for his valuable information. I regret the pressure of our business will not permit of any extended discussion of it now, but I feel that every member will take an opportunity to talk to Mr. Brown and obtain all the information they can at this time, and we will all look into the matter very closely in the near future, as the question is a very live one for most of the members of this association. I thank Mr. Brown for his courtesy in coming here and giving us the information we otherwise probably would not have obtained.

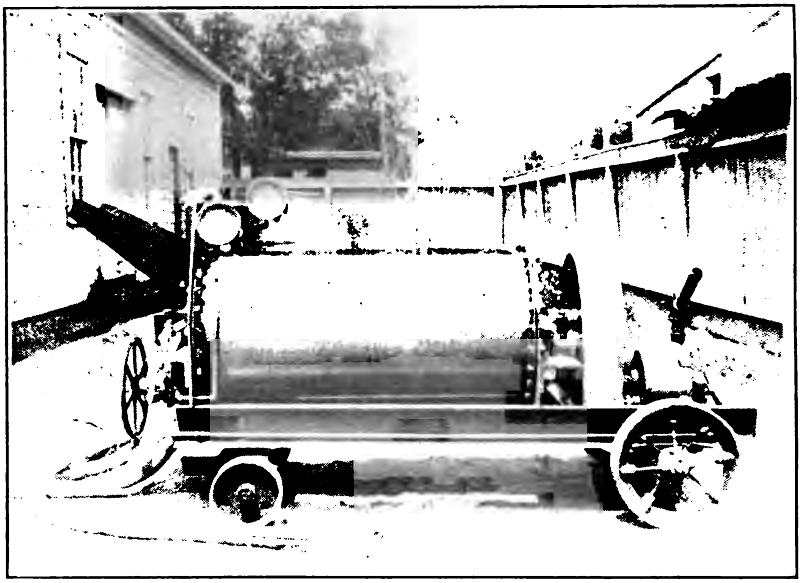


Fig. 1. Concrete Atomizer used on Delaware, Lackawanna & Western R. R.

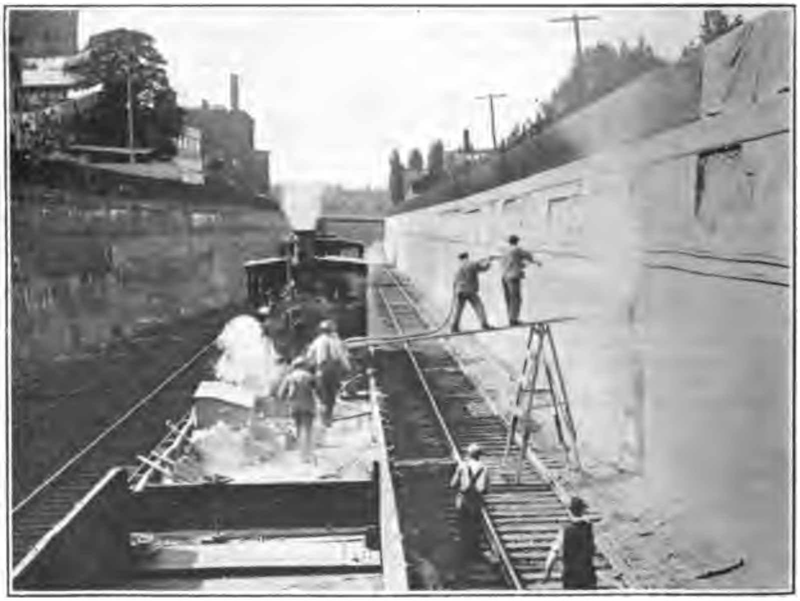


Fig. 2. Repairing Retaining Wall with Concrete Atomizer, Operated by Steam from Locomotive. D. L. & W. R. R.

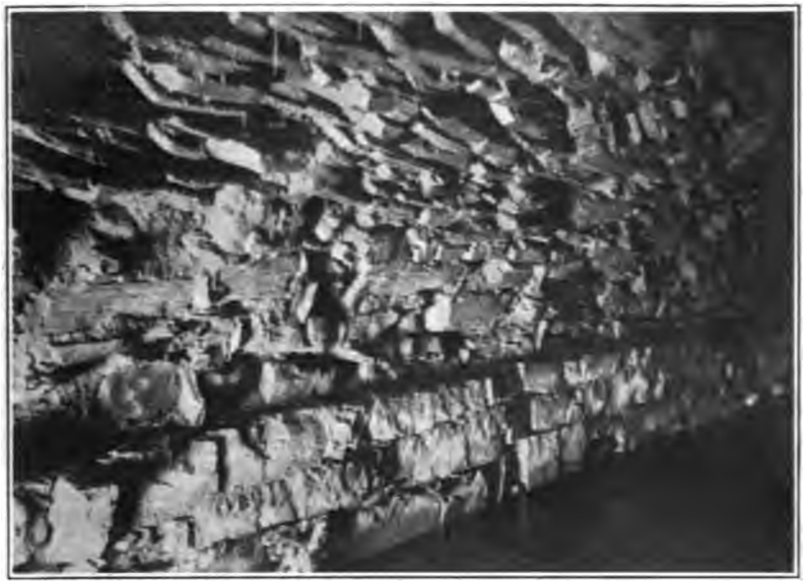


Fig. 3. Conduit at Rupert, Pa., Before Placing Concrete Lining. D. L. & W. R. R.

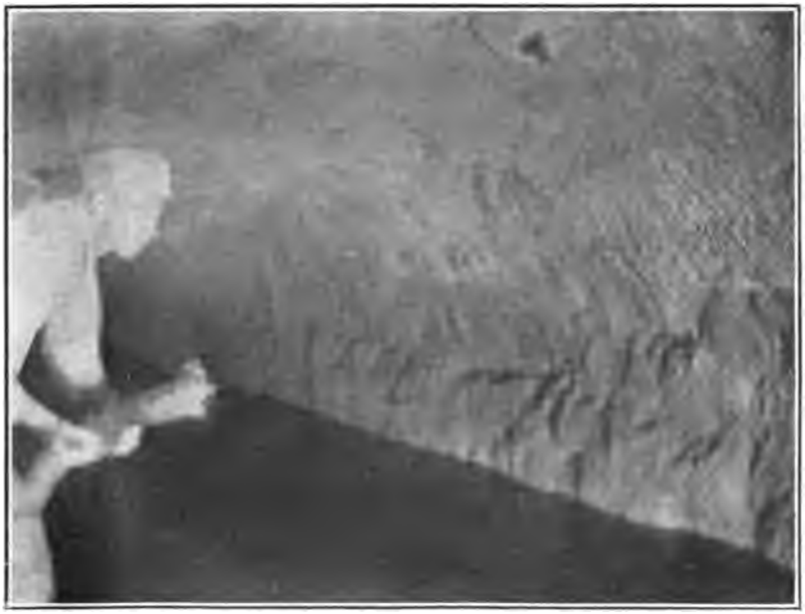


Fig. 4. Conduit at Rupert, Pa., after Re-Lining with Steam-Jetted Concrete.

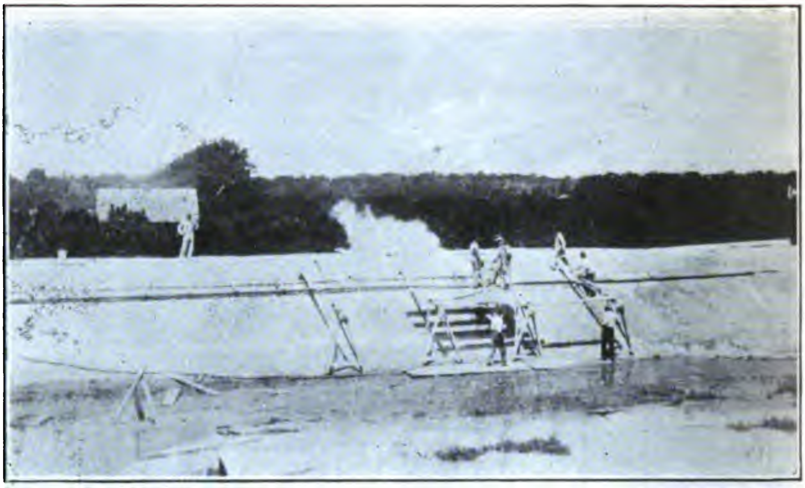


Fig. 5. Steam-Jetted Concrete on U. S. Government Levees below New Orleans.

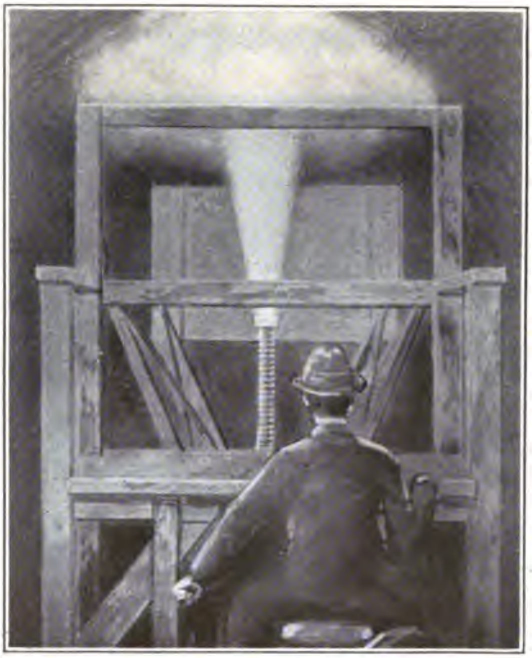


Fig. 6. Nozzle Car and Troweling Machine Applying Steam-Jetted Concrete to Winston Tunnel, Chicago Great Western R. R.

Subject No. 10.

CONCRETE CULVERT PIPE AND CONCRETE PILES.

REPORT OF COMMITTEE.

At the beginning of its work the committee on concrete culvert pipe and concrete piles decided that it was desirable to secure from the railroads, if possible, accurate information concerning the cost of and the extent of the use made of these materials of construction as well as the results of their use with respect to failures, etc. With this in view the chairman asked the different members of the committee to submit lists containing the questions they thought should be addressed to the railroads. From the lists so submitted a tentative set of questions was compiled, which after being subjected to the criticism of the members of the committee, was sent out with a circular letter requesting that the questions be answered. The circular letter was sent to the chief engineers of about 105 roads, including all the railroads in the United States and some in Canada, whose mileage exceeds or approximates 300 miles. In addition, circular letters were addressed to some 32 individual members of the association.

The replies to the questions brought to the committee a great deal of very valuable and interesting matter, a large part of which has been incorporated in the four tabulations which form the principal part of this paper. The replies were still coming in at the time the tabulations were made up and for this reason it is probable that the reports of some few of the railroads may not be included.

While the committee has not had sufficient time to analyze the replies sent in there are certain points which it desires briefly to comment on and for simplicity will deal with each of the two subjects, concrete culvert pipe and concrete piles, separately.

CONCRETE PILES.

On checking over the replies sent in it developed that the following roads have not used concrete piles at all or only to such limited extent that they feel that the results of their experience are not of sufficient interest to be considered by the committee.

Alabama Great Southern.
Algoma Central & Hudson Bay.
Atlantic Coast Line.
Boston & Albany.
Buffalo, Rochester & Pittsburg.
Central of Georgia.
Central of New Jersey.
Central of Vermont.
Chicago & Eastern Illinois.
Cincinnati, New Orleans & Texas Pacific.
Chicago & North Western.
Chicago, Terre Haute & Southeastern.
Colorado Midland.
Delaware, Lackawanna & Western.
Detroit, Toledo & Ironton.
Duluth, Missabe & Northern.
Duluth, South Shore & Atlantic.
Elgin, Joliet & Eastern.
El Paso & Southwestern.
Florida East Coast.
Georgia Southern & Florida.
Hocking Valley.
International & Great Northern.
Kansas City Southern.
Lake Erie & Western.
Michigan Central.
Minneapolis & St. Louis.
Missouri, Kansas & Texas.
Missouri Pacific.
Mobile & Ohio.
New Orleans, Mobile & Chicago.
Norfolk Southern.
Pere Marquette.
Philadelphia & Reading.
Pittsburg, Shawmut & Northern.
Rutland.
Seaboard Air Line.
Southern.
St. Louis Southwestern.
Toledo and Ohio Central.
Toledo, St. Louis & Western.
Union Pacific.
Vandalia.

The following roads have not used concrete piles as yet but have their use under consideration and contemplate using some in the future:

Denver & Rio Grande.
Grand Trunk.
Gulf, Colorado and Santa Fe.
Lehigh Valley.
San Pedro, Los Angeles & Salt Lake.

Concrete piles are used by the railroads for a variety of purposes among which are foundations for buildings, bridges, viaducts, retaining walls, conduits, station platforms, docks, wharves, turntables, cinder pits and for reinforced concrete slab trestle bridges. This last use is of particular interest to the members of the association in that the reinforced concrete pile slab trestle type of construction presents a seemingly perfectly satisfactory and economical solution of the pile and timber bridge replacement question in many instances, for those openings which are too large for small culverts of a permanent character. The Chicago, Burlington and Quincy which was the pioneer road with this type of construction, has constructed about 20 miles of concrete pile trestles, some of which have been in service 8 years. The Chicago, Milwaukee & St. Paul started manufacturing and using concrete piles for concrete trestles in 1912 and since that time upwards of 30,000 lin. ft. have been made and driven. On account of the delay to trains that might be occasioned by driving on main lines of heavy traffic, this company has constructed most of its concrete pile trestles on a second track or on lines where the traffic is not very dense.

The Great Northern, the Illinois Central, the Minneapolis, St. Paul & Sault Ste. Marie, the Northern Pacific and the Wheeling and Lake Erie are among the roads that make considerable use of concrete piles for trestles. The Great Northern now prefers, however, in place of concrete pile bents, slim reinforced concrete piers extending one to two feet below the surface of the ground, and supported on piles, with longitudinal struts for heights above 20 ft.

The committee anticipated that considerable interest would be shown by the members of the association in concrete pile trestles, and consequently inserted the several questions relative to this type of construction. It is seen by referring to the tabulation of the replies that most of the railroads agree that the premoulded reinforced concrete pile is suitable for use in trestle bents, that they allow loads of from 20 to 35 tons per pile and that the penetration required under ordinary conditions varies from about ⅖ to ⅔ the length of the pile, while the maximum projection above the ground recommended varies from 10 ft. to 30 ft. Several roads agree on about 20 ft. for the maximum projection above ground unsupported while some limit this height to about 14 or 16 ft. and build slim concrete piers for greater heights.

The pre-moulded type of pile seems to be preferred by the greater number of roads which is due partly to the necessity of using this type for trestle work. The octagonal, straight-sided pile about 16 in. in diameter appears to be the most used shape. The steel reinforcement of concrete piles should be designed not only to take a portion of the load that may be placed upon the pile after it is driven but also to take care of the bending stresses that occur when the pile is lifted either by the middle or by one end and to withstand the shocks caused in dragging it over rough ground to the leads and the jars occasioned in driving.

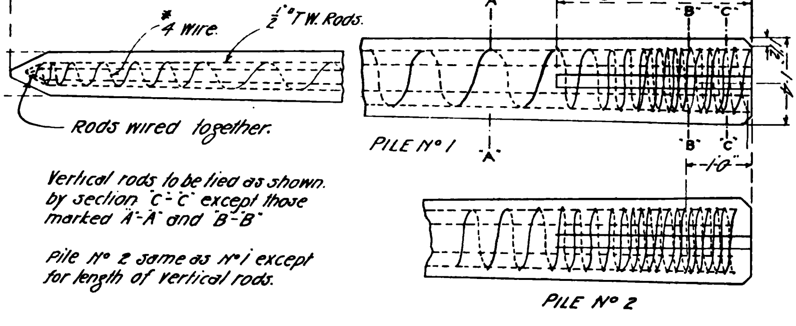
While none of the railroads replying to the list of questions reported using the Bignell patented jet pile the drawing of this pile is reproduced in this report because of the very interesting features connected with its design and method of installation. As will be seen by referring to the drawing the unusual feature of this type of pile is the combination of the main jet pipes with the several lateral jets leading from the main one at certain intervals along the length of the pile. It is possible with this arrangement to sink these piles to any ordinary depth without the use of a hammer.

The tabulation and various drawings show the methods of reinforcement used by the different railroads in considerable detail. It is seen that the Illinois Central on the 40-ft. pile used 8 additional longitudinal rods 16 ft. long in the middle portion, these rods being omitted, however, in the piles of shorter lengths.

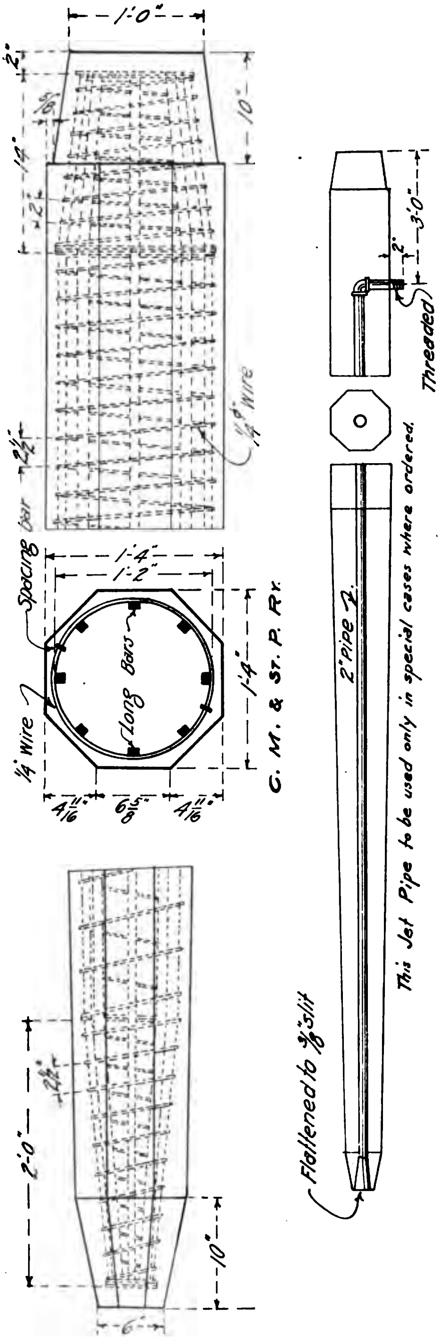
On looking through the tabulation it will be noticed that while a great many different makes and types of piles have been used, it is very comforting to observe that no matter whether the piles were designed, manufactured and installed by manufacturers, contractors or railway forces there have been no failures reported and that very few piles have been broken in handling or in driving and none under load. On the strength of this record it would seem that there should be no need of hesitation on the part of railroad engineers and builders to use concrete piles where the conditions make this type of construction the most economical. The particular type of pile to be used must of necessity depend very largely upon the conditions at the site of the proposed structure or upon the individual ideas of the designer.

The questions as to the cost of concrete piles were formulated with the purpose of segregating, in a general way, the various items which together make up the total cost in place. It was understood that different methods of accounting might tend to cause a somewhat wide variance in these costs but we have endeavored in the tabulation of costs under the head of "remarks" to give as much description as possible regarding the methods used in arriving at the different costs in order to help explain how this variance comes about.

The several photographs which appear in the report are inserted for the purpose of showing some rather extensive and interesting features of the use and manufacture of concrete piles.

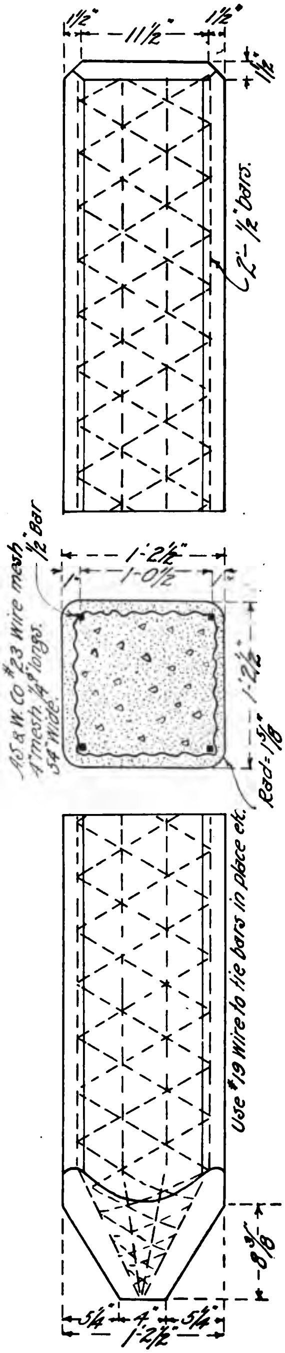

#4 wire to be firmly wired to vertical rods.
2½" Hole
2"
Section 'B-B'
Section 'C-C'
Section 'A-A'
28'-0"
12 @ 3" = 3'-0"
#4 Wire
½" T.W. Rods.
Rods wired together.
A
B
C
Pile No 1
1'-0"
Vertical rods to be tied as shown by section 'C-C' except those marked 'A-A' and 'B-B'
Pile No 2 same as No 1 except for length of vertical rods.
Pile No 2

Long Island R.R., Concrete Piles, Jamaica Platform Shelter Sheds.

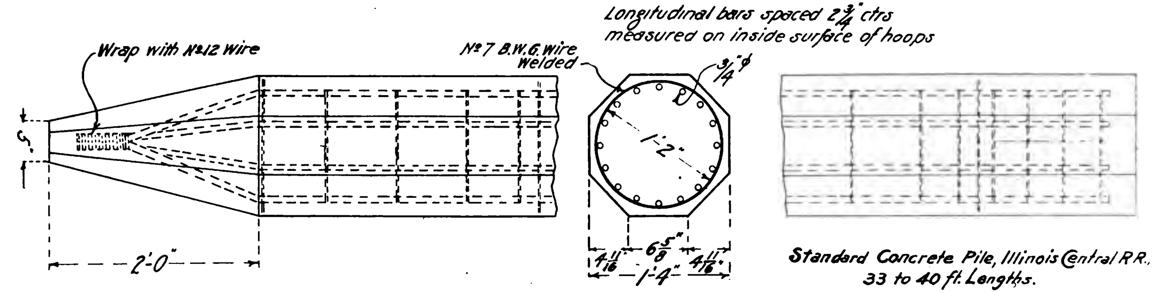


This Jet Pipe to be used only in special cases where ordered.

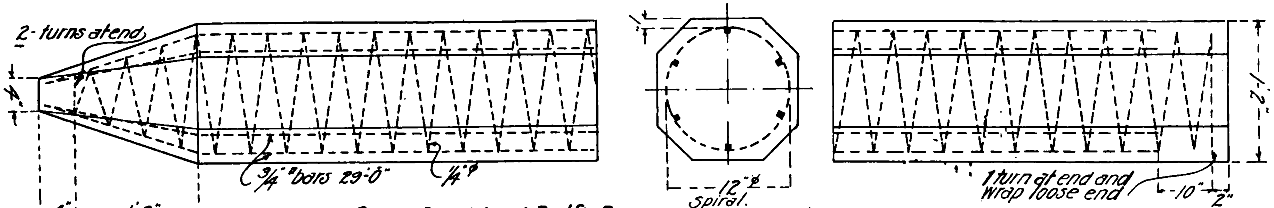
Chicago, Milwaukee & St. Paul, Standard Reinforced Concrete Pile.



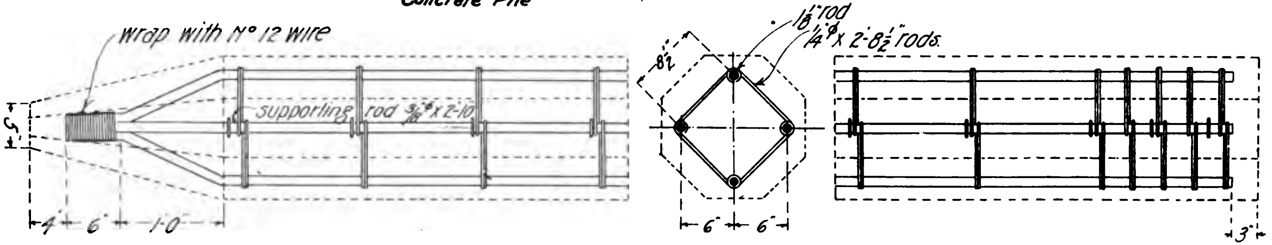
Chicago, Burlington & Quincy, Standard Reinforced Concrete Pile.



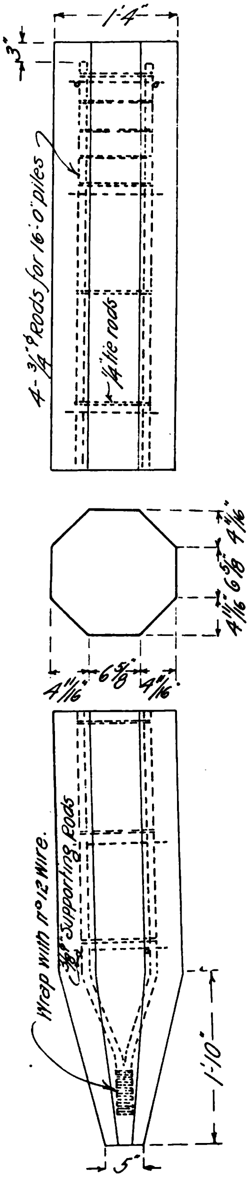
Standard Concrete Pile, Illinois Central R.R., 33 to 40 ft. Lengths.



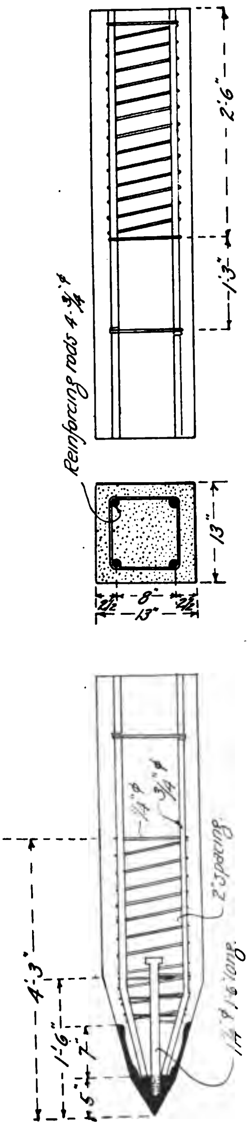
Chicago, Rock Island & Pacific Ry., Concrete Pile



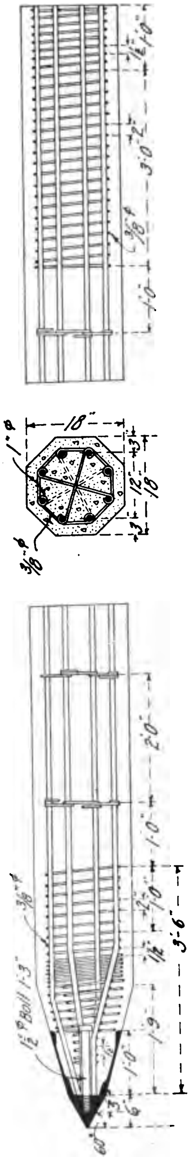
Standard Concrete Pile, Northern Pacific Railway.



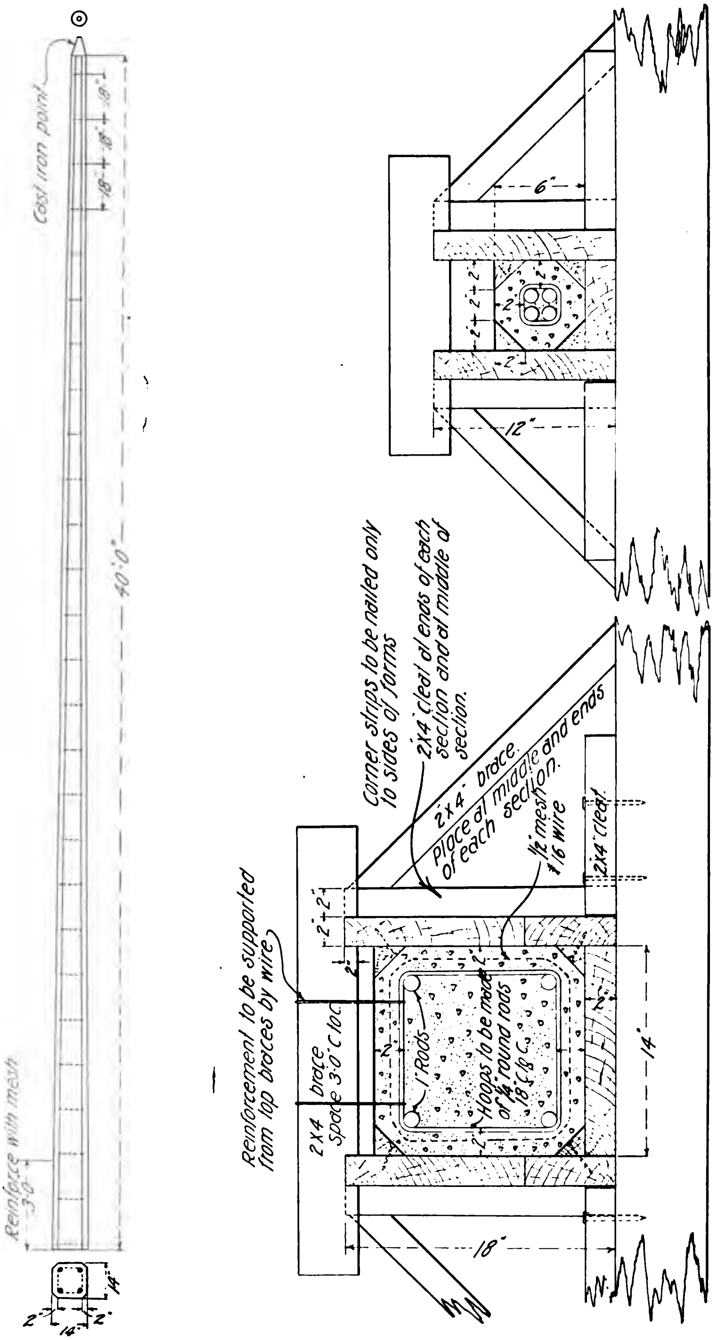
Great Northern Railway, 16 ft. Concrete Pile.



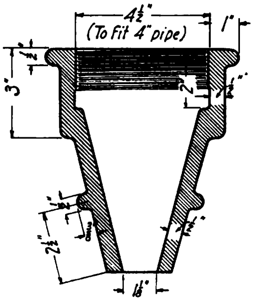
Pennsylvania Railroad, Concrete Pile, Cleveland Track Elevation.

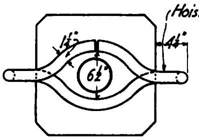


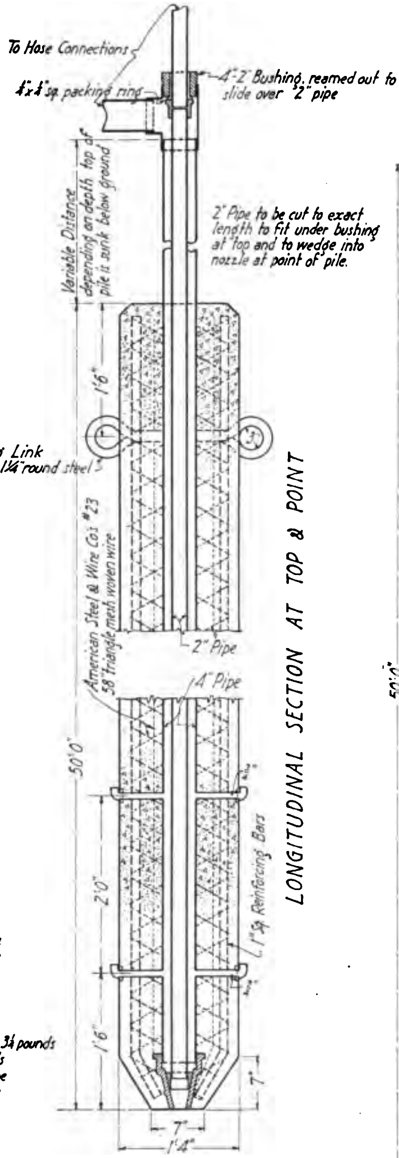
Pennsylvania Railroad, Concrete Pile - Lake Front Ore Dock, Cleveland.


Cast iron point
18"
18"
18"
40'-0"
Reinforce with mesh 3'-0"
2"
14"
2"
14"
Reinforcement to be supported from top braces by wire
2x4 brace Space 3'-0" C to C
1" Rods
Hoops to be made of 1/4" round rods 18" C to C
2"
2"
2"
Corner strips to be nailed only to sides of forms
2x4" cleat at ends of each section and at middle of section.
2x4" brace.
place at middle and ends of each section.
1/2" mesh #16 wire
2x4" cleat
14"
18"
6"
12"

Reinforced Concrete Piles, Wheeling & Lake Erie Railroad.

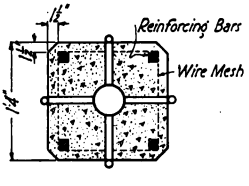




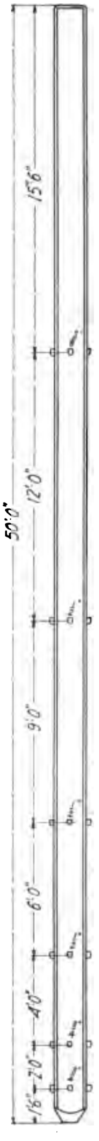

To Hose Connections
¼"x¼" sq. packing ring
4"-2" Bushing, reamed out to slide over 2" pipe
2" Pipe to be cut to exact length to fit under bushing at top and to wedge into nozzle at point of pile.
Variable Distance depending on depth top of pile is sunk below ground
1'6"
American Steel & Wire Co's #23 58" triangle mesh woven wire
2" Pipe
4" Pipe
50'0"
2'0"
1" Sq. Reinforcing Bars
1'6"
7"
7"
1'4"
LONGITUDINAL SECTION AT TOP & POINT

BILL OF MATERIAL

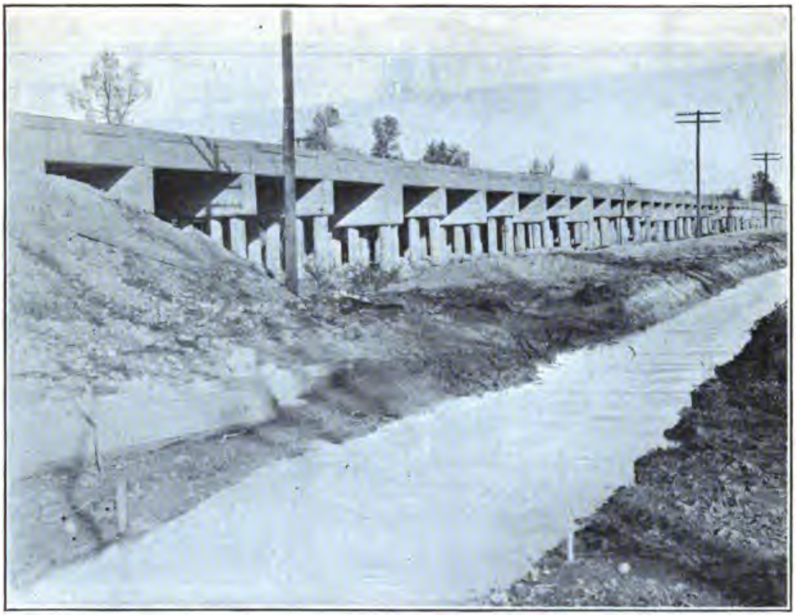
Concrete 3.03 cu. yds. 4.0 bbls. Cement
1.5 Cu. Yds. Sand
1⅞ Cu. Yds. Stone
Reinforcing Bars-4 pcs. 1" square, 50'0" long.
" Mesh, 50'-#23, 58" wide
Nozzle Casting, weight approx. 17½ pounds
Beveled Bushing, wrot iron, weight approx. 3¼ pounds
Hoisting Link. 5' of 1¼" Rd. steel, 21 pounds
Wrot Iron Pipe, 2½ lengths, 50'± of 4" pipe
" " " 4 pcs. ¾"-6' long, 8-¾" Ells
" " " 12 " ½" 6' " 12-½" "
" " " 4 " ⅜" 6' " 4-⅜" "
Approx. Total weight of pile, 6⅓ tons.



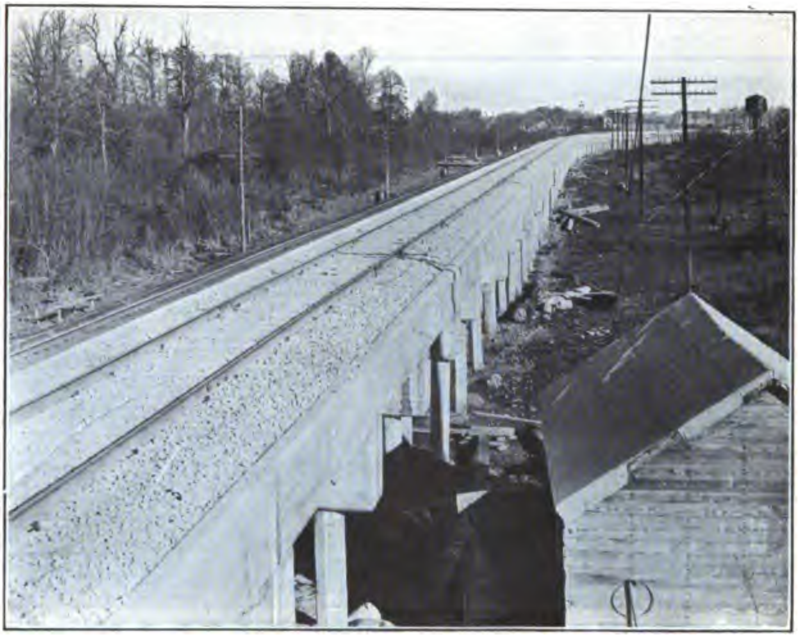
CONSTRUCTION DETAILS OF
PREMOULDED REINFORCED CONCRETE PILE
1'4"x1'4"x50'0"



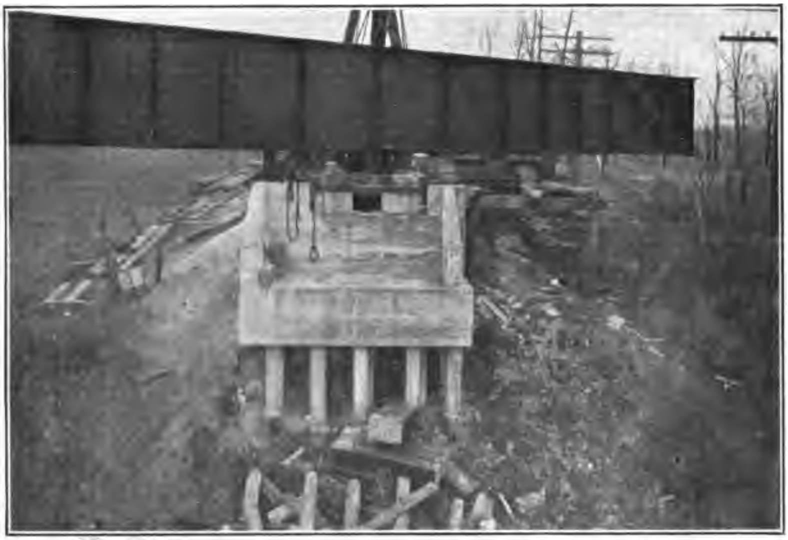
SKETCH SHOWING LOCATION OF SIDE JETS
BIGNELL CONCRETE PILE.



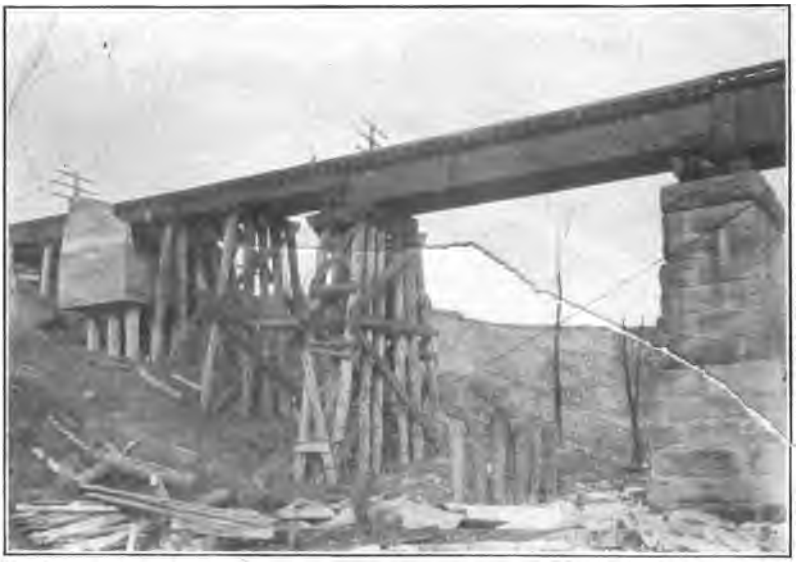
Concrete Pile Bridge, Illinois Central R. R.



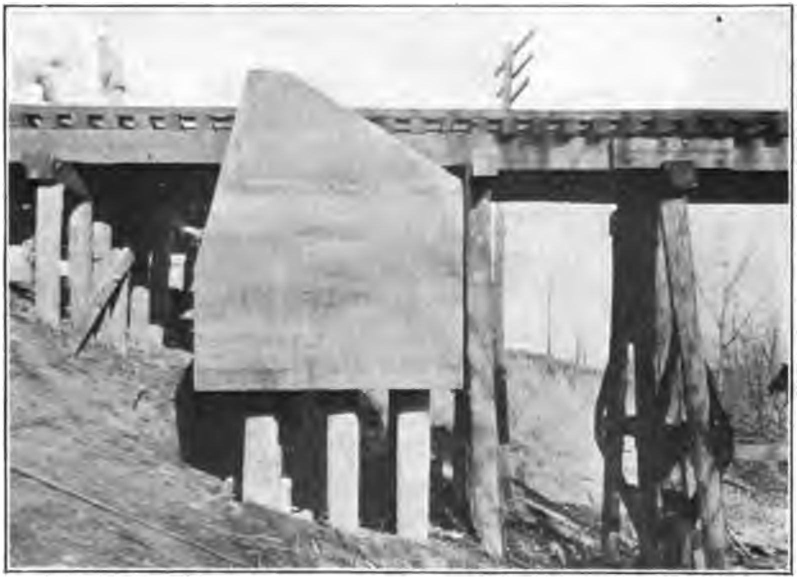
Ballast Deck Concrete Pile Trestle, Illinois Central R. R.



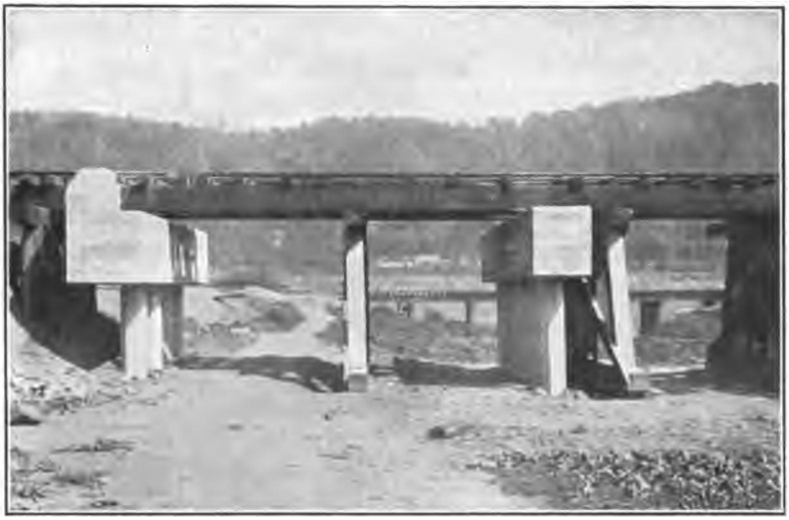
Concrete Piles, W. & L. E. R. R.



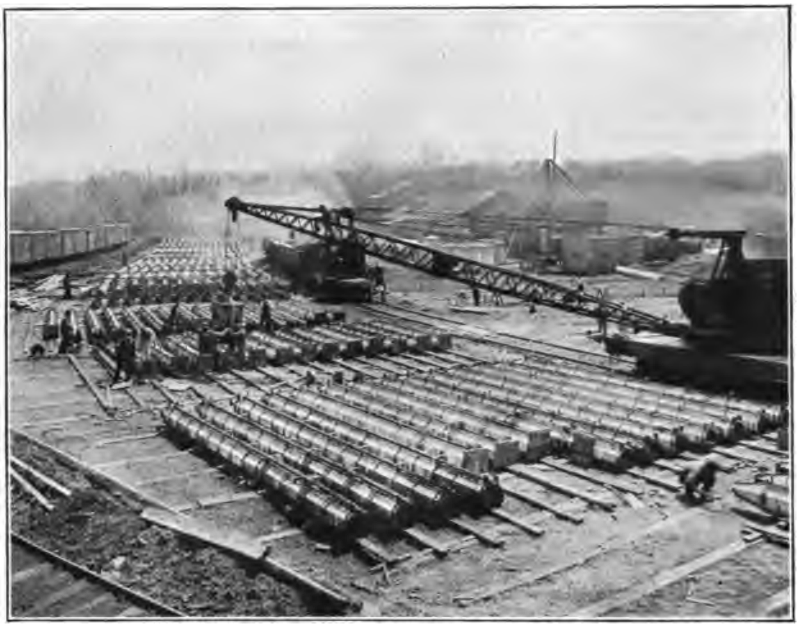
Concrete Piles Supporting Abutment, W. & L. E. R. R.



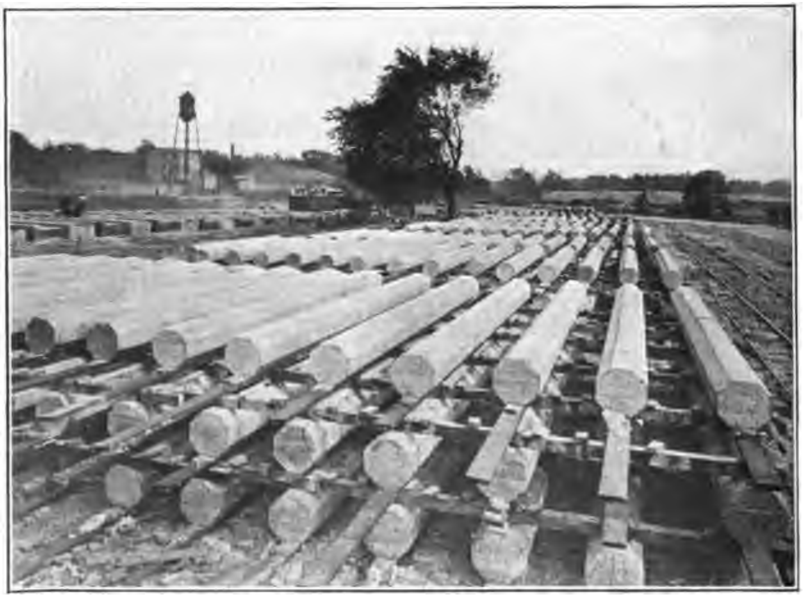
Concrete Piles Supporting Abutment, W. & L. E. R. R.



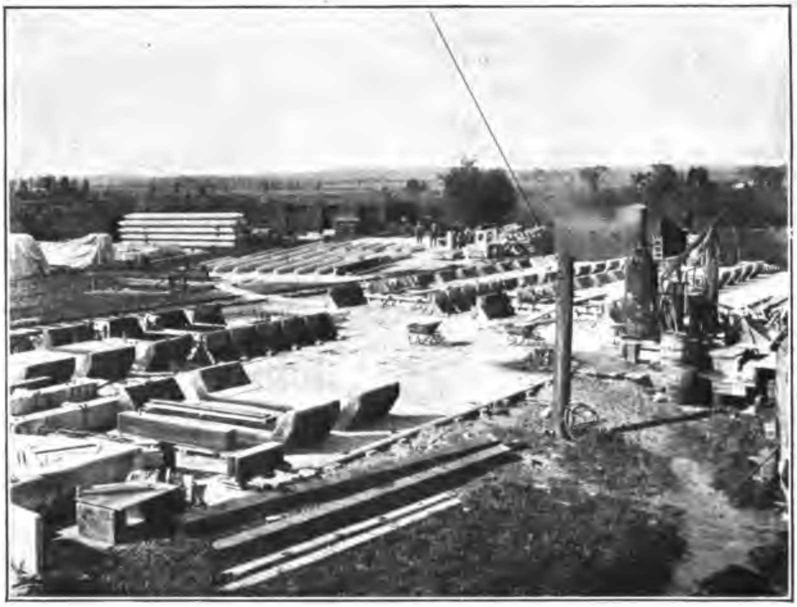
Concrete Piles, W. & L. E. R. R.



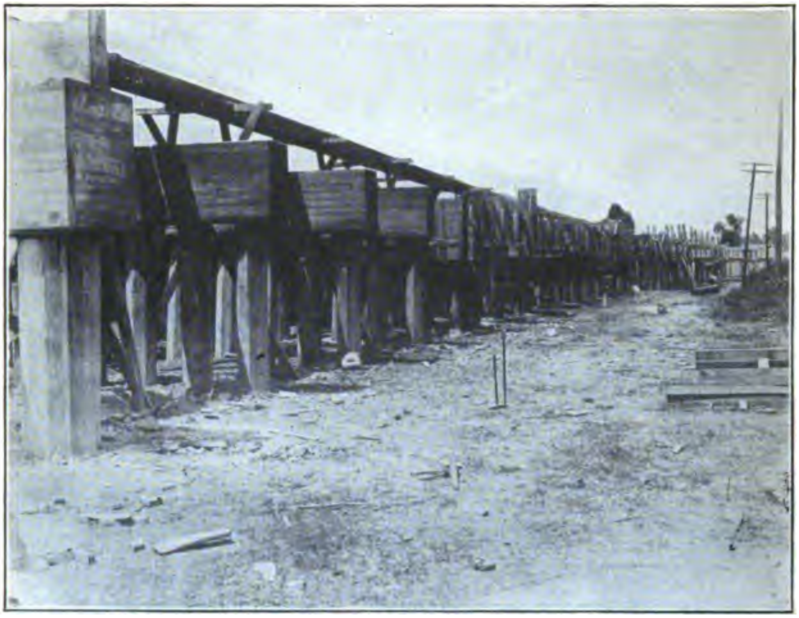
Plant of the C. F. Massey Concrete Pile Yard at Memphis, Tenn.



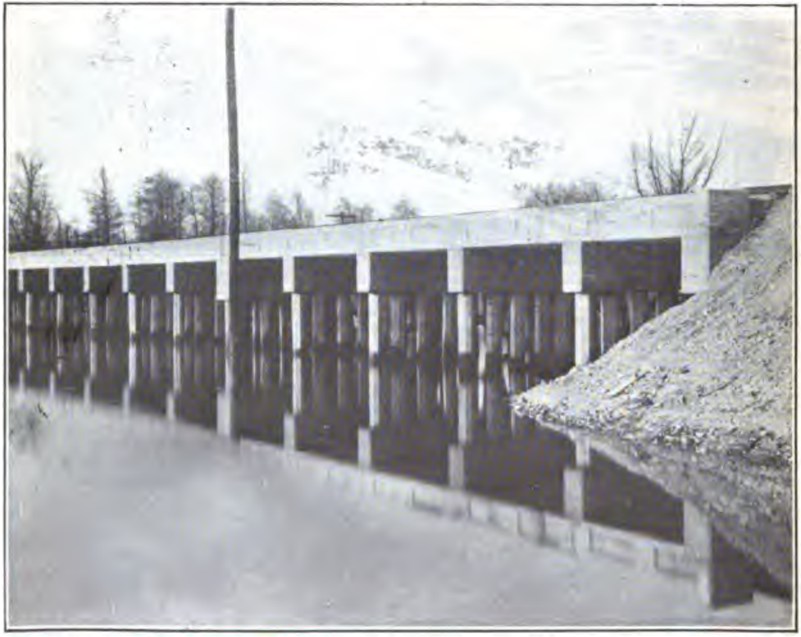
Plant of the C. F. Massey Concrete Pile Yard at Memphis, Tenn.



Concrete Pile and Slab Yard, C. M. & St. P. Ry., at Tomah, Wis.



Method of Casting Concrete Caps on Concrete Piles.



Concrete Pile Bridge, Illinois Central R. R.

Concrete Piles.

Tabulation of Replies to Circular Letter Concerning Costs.

Railroad.	Cost Complete at Point of Manufacture of Piles Purchased Per. Lin. Ft.	Cost Complete at Point of Manufacture of Piles Made by Railway Co. Per Lin. Ft.	Cost of Loading Per Lin. Ft.	Cost of Transporting to Site Per Lin. Ft.	Cost of Unloading Per Lin. Ft.	Cost of Driving Per Lin. Ft.	Cost Complete in Place of Piles Purchased Per Lin. Ft.	Cost Complete in Place of Piles Made by Railway Co. Per Lin. Ft.	Remarks.
Boston and Maine R.R.	.70 .60								For 38121 lin. ft. MacArthur cast in place pedestal piles. All over 38121' " " " " "
Chicago Burlington and Quincy R.R.		.30 .48	.005		.02	About the same as wooden piles varies with conditions		Widely variable	Charged out at .30 on company work not including unloading raw material or loading finished product. This covers actual cost of labor and material only plus 5% for supervision. Charged out on joint work at .48 where all costs such as loading, interest on investment, supervision and accounting, taxes, insurance, depreciation. Commercial rates on haul are included. Pre-moulded piles.
Chicago Milwaukee & St. Paul Ry.		.60 to .70	No data	No data	No data	Varies with conditions .35 to .55		$1.10 to $2.00	For the pile with ¾" longitudinal reinforcing as now used exclusive of transp. charges depending on lenghts & driving cond. These driving costs where no intereference with traffic. Pre-m'ld.
Chicago Rock Island & Pacific Ry.		.67 to .85	No record	No record	No record	.35 to .50		1.02 to 1.35	Cost depends upon number ft. manufactured & driven. Pre-m'ld.
Chicago St. Paul Minneapolis & Omaha Ry.	.85 .85 1.23						.85 .85 1.23		Simplex cast in place 9878 lin. ft. piles 25 to 40 ft. lg. Raymond " " " 49702 " " " 18 to 30 " " Raymond " " " 2595 " " " 16 to 19 " "
Delaware & Hudson Co.							1.00		Price includes manufacture, transp. & driving. Pre-m'ld & c. i. place.
Great Northern Ry.							1.00		Exclusive of transp. Pre-m'ld Ry. Co. design. C. F. Massey Co. Mfgr.
Illinois Central R.R.	20 ft. .60 25 " .64 30 " .58 35-40 .80			.002 per ton per mile	.12	.21	.99		Pre-moulded Railway Co. design C. F. Massey, Co. Mfgr
Long Island Ry	Chenoweth 1.00 Raymond 1.25	.50 to .60	.01	.01	.01	Chen. .15 to .20 Moulded .10	Chenoweth 1.25 Raymond 1.25	.60 to 75	Increase in driving cost on account of delay due to breakage. Pre-moulded and cast in place.
Minneapolis St. Paul & Sault Sainte Marie Ry.	.80 to 1.10 depends on l'gth		.02	.12 200 miles	.02	27 to .33	1.33		Pre-moulded. C. F. Massey Co. design & manufacture.
New-York Central R.R.							1.30 to 1.50		Cummings pre-moulded. Raymond. Cast in place.
New York New Haven & Hartford R.R.	.94						.94		Simplex in 1906, 191 piles, longest 38'-10." Shortest 22'-10." Aver. 30'-9" Prices in general vary from .86 to 2.50 depending on size of job et
Northern Pacific Ry.		.88							Including plant charges. Pre-moulded.
Pennsylvania Lines. (West of Pittsburg)	.90 to 1.10		Data not available	Data not available	Data not available	Contract prices .25 to .35	1.05 1.38 1.50 1.32 1.45 1.15 1.25		500 Simplex piles for building foundation. 384 Simplex piles for underpining building foundation. 280 Chenoweth piles for retaining wall foundation. 289 Cummings piles for bridge abutments & retaining walls, driven in the open 1.32, driven under tracks 1.45. Great Lakes Dredge & Dock Co. piles 30' to 40' lg. for dock wor Great Lakes Dredge & Dock Co. piles 16' lg. retaining wall fnd.
Southern Pacific Co.		.91						91	C.I.P. 198 piles. 4222 lin. ft. av. 21.3' casing per lin. ft. .74 concrete
Wheeling & Lake Erie R.R.	.75 to .85	.975	Included in previous cost prices	See remarks	Variable	.095 to .1575	.92	1.095	Cost of transporting would be for piles purchased from mfg. plan 23¢ per lin. ft. = regular tariff rate plus switching charges. For piles from companys plant to same point 10¢ per lin. ft. = regular tariff. Freight rate not included in cost prices. As there was no freight charge on our line.

RAILROAD	DO YOU USE CONCRETE PILES ?	FOR WHAT PURPOSES HAVE YOU USED THEM ?	WERE THOSE USED OF THE PRE-MOULDED OR CAST IN PLACE TYPE ?
BOSTON & MAINE R.R. **A**	*YES*	*SHOP BUILDING FOUNDATIONS*	*CAST IN PLACE*
CHICAGO ST. PAUL MINNEAPOLIS & OMAHA RY. **B**	*YES*	*FOUNDATIONS FOR BUILDINGS, ENGINE HOUSES, TURNTABLES & CINDER PITS.*	*SIMPLEX CAST IN PLACE RAYMOND*
CHICAGO BURLINGTON & QUINCY R.R. **C**	*YES*	*FOR ALL PURPOSES FOR WHICH PILES ARE USUALLY USED*	*PRE-MOULDED*
CHICAGO MILWAUKEE & ST. PAUL RY. **D**	*YES*	*CONCRETE PILE TRESTLES ENDS OF TAIL, WALLS "U" ABTS*	*PRE-MOULDED*
CHICAGO ROCK ISLAND & PACIFIC RY. **E**	*YES*	*FOUNDATIONS WHERE WOODEN PILING IS NOT SUITABLE*	*BOTH*
DELAWARE & HUDSON CO. **F**	*YES*	*FOUNDADTIONS FOR BRIDGES, CULVERTS & BUILDINGS.*	*BOTH*
GREAT NORTHERN RY. **G**	*YES SINCE 1913*	*CONCRETE TRESTLES PIERS, ABTS & FNDTS IN GENERAL WHERE CUTOFF IS ABOVE L.W.*	*PRE-MOULDED*
ILLINOIS CENTRAL R.R. **H**	*YES*	*TRESTLES AND FOUNDATIONS*	*PRE-MOULDED*
LONG ISLAND R.R. **J**	*YES*	*FOUNDATIONS FOR CONDUITS, BRIDGES AND STATION PLATFORMS*	*BOTH*
LOUISVILLE & NASHVILLE R.R. **K**	*YES*	*FOUNDATIONS FOR BRIDGE MASONARY & CONCRETE WHARVES.*	*PRE-MOULDED*
MINNEAPOLIS ST. PAUL & SAULT SAINTE MARIE RY. **L**	*YES*	*IN TRESTLES*	*PRE-MOULDED*
NEW YORK CENTRAL R.R. EAST OF BUFFALO **M**	*YES*	*SUPPORT OF BUILDINGS RETAINING WALLS & ABUTMENTS*	*BOTH*
NEW YORK NEW HAVEN & HARTFORD R.R. **N**	*YES*	*FOUNDATION FOR A FREIGHT HOUSE.*	*CAST IN PLACE*
NORTHERN PACIFIC RY. **O**	*YES*	*CONCRETE TRESTLE BRIDGES*	*PRE-MOULDED*
PENNSYLVANIA LINES WEST OF PITTSBURG **P**	*YES*	*DOCKS & MASONARY FOUNDATIONS FOR RETAINING WALLS BRIDGES & BLDG'S.*	*BOTH*
SOUTHERN PACIFIC CO. **Q**	*HAVE USED A FEW*	*UNDER PORTION OF PIERS OF THE LOS ALAMOS VIADUCT.*	*CAST IN PLACE*
WHEELING & LAKE ERIE R.R. **R**	*YES*	*ABUTMENTS TRESTLE BENTS* *FOUNDATIONS*	*PRE-MOULDED* *PRE-MOULDED.*

	WHICH TYPE DO YOU PREFER WHY?	WHAT ARE THE PHYSICAL CHARACTERISTICS OF THE PILES AS TO										
		LENGTH	SHAPE	TIP DIMENSIONS BASE POINT LENGTH	TIP SHAPE BASE POINT	TIP CONSTRUCTION	BUTT DIMENSIONS	BUTT SHAPE	BUTT CONSTRUCTION	JET PIPE	WEIGHT PER FOOT	SPECIAL FEATURES
A	DETERMINED BY BIDS	25' TO 35'.	ROUND STR. SIDES	16" ABOUT 3 " 5	ROUND BULB SHAPE	PLAIN CONC. PEDESTAL	16"	ROUND	PLAIN CONC.			
B	FOR ORDINARY WORK WITHIN LIMITS OF SYSTEM PERMANENT FORM C.I.P	SIMPLEX 25 TO 40' RAYMOND 18 TO 30	ROUND STR. SIDES ROUND TAPERED	15" – 8" –	ROUND POINT ROUND	PLAIN CONC. C.I. POINT PLAIN CONC. S.I. BOOT	SIMPLEX 16" RAYMOND 20 TO 30	ROUND ROUND	PLAIN CONC. PLAIN CONC.		190# AVER. 190#	SIMPLEX DETACHABLE C.I. PT METHOD RAYMOND STD. 20"x8"x30' CORE
C	PRE-MOULDED CHEAPER NO PATENTS	15' TO 30'	SQUARE STR. SIDES	14½" 4" DIA. 8⅜"	SQUARE CIRCLE	SPL. RFNG	14½"	SQUARE CORNERS BEVELED 1½"	SAME AS BALANCE	NONE		
D	PRE-MOULDED CAN BE EXAMINED BEFORE DRIVING & LOADED AT ONCE.	16' TO 38'	OCTAG. PART STR. SIDE PART TAPERED	10" 6" 10"	OCTAG. OCTAG.	RFD CONC.	16" OCT. 14" CIR. 12" CIR. 10' LONG	FRUST. OF A CONE 10' LG.	SPECIAL RFNG	IN SPECIAL CASES	STR. PART 220# TAPERED AVG. 144	BEGINS TO TAPER 15'-2" FROM BOT. BALANCE STR. EXCEPT 10' BUTT
E	PRE-MOULDED WHERE IT CAUSES NO DELAY TO WORK STRONGER	30'	OCTAGONAL STR. SIDES	14" 4" 18"	OCTAG. SQUARE	RFD CONC.	14"	OCTAGONAL CORNERS CHAMFD	¼" Φ SPIRAL RFNG 2½" SPA.	NONE	167#	
F	ALL A QUESTION OF PRICE IF SURE PREMOULDED CAN BE DRIVEN	25' TO 30'	SQUARE TAPERED ROUND TAPERED	8"x8" OR 8" DIA. —	SQUARE OR CIRCLE —	CAST IRON POINT	14"x14" OR 20" DIA.	SQUARE OR ROUND	⅜" Φ SPIRAL RFNG 3" SPAC.	NONE		
G	PRE-MLDED CAN BE HANDLED & DRIVEN ABOUT SAME AS WOOD BETTER KNOWL'DG OF CA	16'-0" 20'-6" 25'-0" 29'-6" 34'-0"	OCTAGONAL SQUARE SIDES	16" 5" 1'-10"	OCTAG. OCTAG.	RFD CONC.	16"	OCTAGONAL	RFD CONC. TIE RODS ⅜" Φ 4 SP. @ 3⅜"	NONE	220#	
H	PRE-MLDED ON ACC'T BEING USED IN TRESTLES WHERE THEY PROJECT AB'VE GROUND	20'-0" 25'-0" 30'-0" 35'-0" 40'-0"	OCTAGONAL STRAIGHT SIDES	16" 5" 2'-0"	OCTAG. OCTAG.	RFD CONC.	16'	OCTAGONAL	RFD CONC. HOOPS #7 WIRE 4" SPAC'G	NONE		
J	PRE-MOULDED CHEAPER BETTER	15' TO 28'	OCTAGONAL TAPERED	15' 28' 10-11" 7-8" 1" 1" 8" 8"	OCTAG.	RFD CONC. POINTED	14" TO 16"	OCTAG.	No 4 WIRE SPIRAL 2" HOLE 3' DEEP			2" DIA. HOLE 3' DEEP IN BUTT
K	PRE-MLDED ACC'T ASSURANCE OF OBTAINING GOOD CONC. & FULL SECTION.	UP TO 45'	SQUARE TAPERED	9"x9"	SQUARE	RFD CONC. BLUNT POINTED	14"x14"	SQUARE				
L	PRE-MOULDED BECAUSE THE TRAFFIC CAN BE MOVED MORE QUICKLY	12' TO 60'	HEXAGONAL STR. SIDES	16" 4" 2'-0"	HEXAG. "	RFD CONC.	16"	OCTAG.	RFD CONC.		220#	
M	QUESTION OF COST ONLY IF IN C.I.P. TYPE WATER PROOF SHELL IS LEFT IN PLACE.	PRE-MLD 25 TO 40 C. IN P. 25 TO 30	OCTAG. TAPERED ROUND TAPERED	9" = 8" =	OCTAG. " ROUND "		18" 20"	OCTAG. ROUND				
N	C.I.P. IF SPACED FAR ENOUGH LOCAL CONDITIONS MIGHT DETERM'E TYPE	UP TO 40'	ROUND STR. SIDED	16" 10"	ROUND	CAST IRON CONICAL POINT	16"	ROUND	PLAIN CONC.			CONCRETE MIXTURE 1-2½-5
O	PRE-MOULDED	16'-0" 20'-6" 25'-0" 29'-6"	OCTAGONAL STR. SIDES	16" 5" 1'-10"	OCTAG. OCTAG.	RFD CONC.	16"	OCTAG.	RFD CONC.	NO	220#	
P	PRE-MOULDED WHERE MATERIAL IS EXTREMELY SOFT OR WHERE DEPTH OF PENETRATION PREVIOUSLY KNOWN OR WHERE PORTION OF PILES PROJECT ABOVE GROUND CAST IN PLACE WHERE MATERIAL IS NOT TOO SOFT OR WHERE DEPTH OF ROCK IS UNKNOWN.	30' & 40'	OCTAGONAL STR. SIDES	18" 0" 2'-3"	OCTAG. POINT	CONICAL IRON PT. SCREWED ON 1½" BOLT	18"	OCTAG.	RFD CONC. SPIRAL ⅜" Φ 1½" SP.	NO		
		24'	RECTANGULAR STR. SIDES	10"x12" 10"x3" ABOUT 8"	RECTG'LR RECTG'LR	BENT PLATE 10"x10"x⅜"	10"x12"	RECTG'LR	RFD CONC. SPIRAL ½" Φ 1½" SP.			
		16'	SQUARE STR. SIDES	13"x13" 0 1'-6"	SQUARE POINT	CONICAL IRON PT. SCREWED ON 1½" BOLT	13"x13"	SQUARE	RFD CONC. SPIRAL ¼" Φ 2" SP.			
Q		21'	ROUND STR. SIDES	10" 10"	ROUND	PLAIN CONC.	10"	ROUND	PLAIN CONC.			DOUBLE STOVE (PIPE) No 16 STEEL WELL CASING USED FOR FORMS
R	PRE-MOULDED NO NO EXTRA EQUIP. DEFECTS SHOW UP AS SOON AS HAMMER HITS PILE. NO DANGER OF A COLLAPSED SHELL OR SQUEEZING GREEN CON. BY ADJ. PILES.	20' TO 40' 40'	OCTAG. STR. SIDES SQUARE TAPERED	16" 16" 2'-2" 6" — ABOUT 8"	OCTAG. POINT CONICAL OCTAG. POINT CONICAL	RFD CONC. CAST IRON PT. RFD CONC. CAST IRON PT.	16" 14"	OCTAG. SQUARE CORNERS BEVELED	RFD CONC. RFD CONC. ⅝" MESH No 16 WIRE FOR 3'			

	WHAT IS THE NATURE OF THE REINFORCEMENT							DO YOU MAKE YOUR OWN CONCRETE PILES?	DO YOU HAVE CENTRAL DIVISION OR MOVABLE PLANTS?	WHAT IS THE CAPACITY OF PLANT LINEAL FEET PER DAY?
	LONGITUDINAL			TRANSVERSE			SPECIAL REINFORCEMENT			
	ROWS	SIZE	SPACING	ROWS	SIZE	SPACING				
A								NO		
B							NO REINFORCEMENT. RAYMOND NON-RFD SHELL	NO		
C	4 RODS ONE IN EACH CORNER	1/2" □ CORR.		A.S. & W. CO. #23 WIRE MESH 1/4" Φ LONGITUDINALS MESH 54" WIDE				YES	THREE PLANTS ON 9000 MILES	EACH PLANT 500 1500 TOTAL
D	OVER 30 8 RODS 25 TO 30 UNDER 25	8-3/4" □ 6-5/8" □ 8-1/2" □	EQUAL " "	SPIRAL " "	1/4" PL. Φ " "	4" " "	SPECIAL SPIRALS FOR POINTS & CAPS	YES	CENTRAL ALSO AT SITE OF SPECL STRUCTURES IF AGGREGATE HANDY	VARIED TO SUIT THE DEMAND
E	6 RODS	3/4" □ CORR. 29'-0"	EQUAL WITHIN 12" DIA. CIRCLE	SPIRAL 46 SPACES 40 " 34 "	1/4" PL. Φ	2 1/2" 3" 3 1/2"	CLOSEST SPACING IS AT THE BUTT.	PRE-MOULDED YES CAST IN PLACE NO	USUALLY MANUFACTURE AT THE SITE	
F	4 RODS 4 RODS	3/4" Φ 1/2" Φ	1 EACH CORNER 1 EACH SIDE	50 ROWS RAYMOND TYPE SPIRAL REINFORCING	3/8"	ENDS 3 CEN. 12	PRE-MLD SQ. C.I. SHOE CAST IN PLACE ROUND PILES	NO		
G	16-25 4 RODS 29 1/2-34 8 RODS	3/4, 7/8 & 1 1/8 Φ 7/8 & 1" Φ	EQUAL	TIE RDS	1/4" Φ	BUTT 4 @ 3 3/8 BALANCE 13 1/2"	2 TIE PLATES 2 1/4 × 1/8 × 15 3/4 EVERY 28" 2 HOLES FOR LG RDS	NO	NONE	
H	FOR 40' 8 RODS 4 " 4 "	7/8 Φ × 16 7/8 Φ × 39 1/2 7/8 Φ × 37 1/2	2 3/4 CTS " "	#7 BWG WIRE HOOPS WELDED	#7 BWG WIRE	5 @ 4" 54 @ 6"	ONE 1/4 Φ SPACING ROD LOOPED AROUND 2 LG RDS EVERY 27'	NO		
J	15' PILE 8 RODS 28' PILE 8 RODS	1/4" □ 1/2" □	EQUAL EQUAL		No 4 WIRE No 4 WIRE	ENDS 3" CENT. 6" & 12"		YES	MANUFACTURE AS NEAR THE JOB AS POSSIBLE NO FIXED PLANT	WITH HAND LABOR 300 LIN. FT.
K	4 RODS ONE IN EACH CORNER	1" OR 1 1/4"	EQUAL		1/4" OR 3/8" TIES	3" TO 12"	NONE EXCEPT SOMETIMES INCREASE RENFG AT ENDS	YES	NO SPECIAL PLANT PILES MADE AT SITE OF WORK	
L	ROUND BARS	VARIES WITH LENGTH	VARIES WITH LENGTH		No 6 WIRE WRAPPED AROUND VERTICAL BARS			NO	MANUFACTURERS PLANT LOCATED ON OUR LINE	2000
M	8 RODS 8 RODS 10' LG	1/2" TO 5/8" 3/4"	EQUAL		#5 WIRE	3" PITCH	SPIRAL ROD RENFG IN HEAD	NO		
N	NONE			NONE				NO	NONE	
O	4 RODS	1 1/8" Φ	EQUAL	TIE RODS FLAT BARS	1/4" Φ 2 1/4 × 1/8 × 15 3/4	3 3/8" & 1'-1 1/2" ABOUT 10" & 20	THE CLOSER SPACING OF RODS & BARS IS AT BUTT	YES	CENTRAL	
P	8 RODS	1" Φ	EQUAL	BUTT & TIP WRAPPING TIE RODS BRACE RD	3/8 Φ 3/8 Φ 3/8 Φ	1 1/2 & 2" 24"	TWO BRACE RODS ABOUT EVERY 24"	NO	NONE	
	8 RODS 1 EA. COR SHORT SD LONG SD	3/4 Φ 3/4 Φ 7/16 Φ	IN CENT. IN CENT.	BUTT & TIP WRAPPING TIE RODS BRACE RD	3/8 Φ 3/8 Φ 3/8 Φ	1 1/2, 2 & 3 24"	BRACE ROD ABOUT EVERY 24"			
	4 RODS ONE IN EACH CORNER	3/4" Φ	EQUAL	BUTT & TIPP WRAPPING TIE RODS	1/4 Φ 1/4 Φ	2" 24"				
Q	NONE			NONE				YES	MADE AT SITE OF WORK	CASINGS SUNK AT RATE OF ABOUT 50 FT. PER DAY FOR EACH OUTFIT.
R	8 RODS 4 RODS IN EACH CORNER	1/2" Φ 1" Φ CORR.	EQUAL EQUAL	BUTT & TIPP WRAPPING RINGS CROSS TIE ROD BUTT. WRAPPING RINGS	1/4" Φ 1/4" Φ No 16 WIRE 1/4" Φ CORR.	2 1/4" FOR 3 1/2 16" 1/2" FOR 3' 18"	AT EACH RING SAME SPACING END TO END	THIS TYPE PURCHASED THIS TYPE MADE BY OUR OWN FORCES	COMPANY PLANT IS CENTRAL	MANUFACTURE'S PLANT 2000 RAILWAY CO'S PLANT 120

	WHAT IS THE STORAGE CAPACITY LINEAL FEET ?	HOW LONG ARE PILES LEFT IN THE FORMS BEFORE MOVING ?	HOW LONG ARE PILES LEFT IN YARD BEFORE DRIVING ?	IF PILES ARE PURCHASED WHO IS THE MANUFACTURER ?	DOES RY. CO. OR MANUFACTURER MAKE DESIGN AND WRITE SPECIFICATIONS ?	WHAT EQUIPMENT IS USED IN DRIVING THE PILES STD DRIVER SPECIAL DRIVER JETTING PLANT
A				MC ARTHUR CONCRETE PILE & FOUNDATION CO H. ABBOTT, INVENTOR	MANAFACTURER	STANDARD WITH EXTRA RIGGING FOR PULLING SHELL.
B				SIMPLEX SYSTEM THE FOUNDATION CO RAYMOND SYSTEM G.W. OAKES & CO. LIC.	RAILWAY CO. CONCRETE SPECIFICATIONS AND INSPECTION.	SWING DRIVER SWING DRIVER CONCRETE COUNTB
C	UNLIMITED	ROLLED OFF FORM IN 2 DAYS BUT NOT PICKED UP FOR ONE WEEK	VARIES MINIMUM 30 DAYS		RAILWAY CO.	STANDARD DRIVER AND JET.
D	10,000 LIN. FT. IF NECESSARY	30 DAYS	30 DAYS	NONE	RAILWAY CO.	STANDARD DRIVER JET USED IN SAND
E		24 HOURS	30 TO 45 DAYS	WHEN PURCHASED RAYMOND CONCRETE PILE CO.	RAILWAY CO.	PRE-MOULDED STANDARD CAST IN PLACE SPECIAL JET SOME CASES
F				CONCTRACTORS	DESIGN MFGR SPECIFICATIONS RY. CO. AS TO CONCRETE MIX. ETC.	
G			30 DAYS	C.F. MASSEY CO.	RAILWAY CO., MAKES DESIGN & WRITES SPECIFICATIONS. COPY ATTACHED	BAY CITY NO. 2 BAY CITY NO. 3 CONVERTABLE 40 TON CRANE & DRIVER
H		48 HOURS	45 DAYS	C.F. MASSEY CO.	RAILROAD	BOOM DRIVER WITH JET PLANT WHEN NECCESSARY
J		48 HOURS	3 WEEKS BUT IN GOOD SETTING WEATHER & EASY DRIVING 2 WEEKS	CHENOWETH ROLLED RAYMOND CAST IN PLACE	MANUFACTURER	EITHER LAND OR TRACK DRIVER. NO JET
K		SIDE FORMS STRIPPED IN ONE WEEK NOT MOVED FOR AT LEAST 30 DAYS	30 DAYS MINIMUM			STANDARD DRIVER WATER JET
L	50000	2 TO 24 HOURS	20 DAYS	C.F. MASSEY CO.	MANUFACTURER	
M		30 DAYS	AT LEAST 30 DAYS	CUMMINGS STRUCTURAL CONC. CO RAYMOND CONCRETE PILE CO.	DESIGN MFGR SUBJECT TO APPROVAL SPECIFICATIONS RAILWAY CO.	PRE-MOULDED DRIVEN WITH DROP HAMMER. CORE FOR C.I.P. STEAM
N				NEW ENGLAND FOUNDATION CO. CONCRACTORS SIMPLEX PILES	CONTRACTOR	SPECIAL DRIVER
O		60 DAYS				STANDARD
P		12 TO 18 HOURS	30 DAYS	PRE-MOULDED GREAT LAKES & DOCK CO. CUMMINGS STRUCTURAL STEEL CO. CHENOWETH DESIGN BY AMER. CONCRETE CO. CAST IN PLACE SIMPLEX BY CRANFORD CONSTRUCTION CO.	IN SOME CASES RY. CO. PREPARED THE DESIGN & SPECIFICATION IN OTHER CASES THE DESIGN & SPECIFICATION OF THE MANUFACTURER HAVE BEEN ACCEPTED.	NO SPECIAL EQUIPMENT.
Q						WELLS FOR FORMS BORED WITH AN ORDINARY HAND DRILLING OUTFIT.
R	MANUFACTURE'S PLANT 100,000 RAILWAY CO'S PLANT 50,000	MANUFACTURERS PLANT 10 TO 15 HOURS DEPENDING ON METHOD OF CURING RAILWAY CO'S PLANT 24 HRS.	MANUFACTURERS PLANT 30 DAYS IN OPEN AIR RUSH WORK 7 DAYS IN STEAM RAILWAY CO'S PLANT 30 DAYS IN OPEN AIR	GREAT LAKES DREDGE & DOCK CO.	PILES PURCHASED MADE UNDER MANUFACTURERS DESIGN & SPECIFICATION BUT HIS EQUIPMENT IS SUCH THAT HE CAN MAKE PILES TO OUR SPECIFICATIONS.	STANDARD DRIVER WITH EITHER STEAM OR DROP HAMMER IN SOME CASES JETTING SAVES TIME.

	WHAT EQUIPMENT IS USED IN DRIVING THE PILES ST'D DRIVER SPECIAL DRIVER JETTING PLANT	WHAT TYPE OF HAMMER IS USED ? STEAM OR DROP WEIGHT ? DROP ?	WHAT KIND OF DRIVING CAP DO YOU USE STANDARD OR CUSHION? IS CUSHION OF WOOD ROPE OR OTHER MATERIAL?	HOW DO YOU ARRIVE AT THE MAX. SAFE LOAD ON EACH PILE? IF A FORMULA IS USED PLEASE STATE IT	WHAT PROPORTION OF THE TOTAL NUMBER OF PILES USED WERE BROKEN ?	OF THOSE BROKEN WHAT PROPORTION WERE BROKEN		
						IN HANDLING	IN DRIVING	UNDER LOAD
A	STANDARD WITH EXTRA RIGGING FOR PULLING SHELL.	STEAM NO 2 VULCAN	OAK IN STEAM HAMMER					
B	SWING DRIVER SWING DRIVER CONCRETE COUNTBL	DROP HAMMER STEAM NO 2 VULCAN 3000# 30" STROKE	OAK STRIKING BLOCK.	GENERAL IDEA OF PROPER SAFE LOAD BY USE OF ENG. NEWS FORM.	CAST IN PLACE PILES ARE NOT SUBJECT TO BREAKAGE.			
C	STANDARD DRIVER AND JET.	BOTH	CUSHION	DEPENDS UPON SOIL CONDITIONS NO FORMULA	VERY SMALL			
D	STANDARD DRIVER JET USED IN SAND	DROP & STEAM 15' TO 20' DROP	SPECIAL CAST IRON CAP WITH ROPE CUSHION	PREVIOUS EXPERIENCE WITH WOODEN PILES IS GUIDE	NO RECORD OF ANY BROKEN SOME HEADS DAMAGED.	NONE	SOME HEADS CRUSHED DUE TO HARD DRIVING.	
E	PRE-MOULDED STANDARD CAST IN PLACE SPECIAL JET SOME CASES	STEAM NO 2 VULCAN	CUSHION CAP MADE OF ROPE		NONE	NONE	NONE	NONE
F		STEAM NO 1 VULCAN AND NO 2 VULCAN	WOOD STRIKING BLOCK	$L=\frac{2WH}{S+0.1}$ ENG. NEWS FORM.	5%	NONE	5%	NONE
G	BAY CITY NO. 2 BAY CITY NO 3 CONVERTABLE 40 TON CRANE & DRIVER	BOTH DROP 4500# 6 TO 10 STEAM 4500# ——	ROPE CUSHION ON TOP OF PILE STEEL CYLINDER WITH OAK OR MAPLE FOLLOWER	IF CONDITIONS ARE NOT FAVORABLE FOR DESIGNED LOAD MORE PILES ARE PUT IN	NO RECORD	NO RECORD	NO RECORD	NO RECORD
H	BOOM DRIVER WITH JET PLANT WHEN NECCESSARY	STEAM HAMMER GROSS WEIGHT 6500# PLUNGER " 3000 DROP OF PLUNGER 3'	STEEL EXTENSION DRIVING CAP 8 FT LONG WEIGHT ABOUT 1600#	$L = \frac{2WH}{S+0.1}$	LESS THAN 3%	1%	2%	0
J	EITHER LAND OR TRACK DRIVER NO JET	STEAM VULCAN	CUSHION WOOD		ABOUT 8 BROKEN IN OVER 1000 USED.	7	1 BROKEN IN ATTEMPTING TO STRAIGHTEN	NONE
K	STANDARD DRIVER WATER JET	DROP 3500# MAX 20 FT	CUSHION ROPE. SAW DUST. SHAVINGS. ETC.	DETERMINED BY LOCAL CONDITIONS.	SMALL		PRACTICALLY ALL	
L		STEAM WGT. 6500#	CUSHION CAP OF WOOD		WOOD NOT EXCEED 2%		2%	
M	PRE-MOULDED DRIVEN WITH DROP HAMMER. CORE FOR C.I.P. STEAM	DROP 3 TO 6 TONS 3 TON 12' 6 TON 8' STEAM 6000# WITH 3000# PLUNGER 30"	CUSHION USED IN DRIVING PRE-MOULDED	WHEN IN DOUBT TEST LOADES USED ENG. NEWS FORMULA USED AS A GUIDE.	VERY FEW	NONE	SMALL	NONE
N	SPECIAL DRIVER	DROP HAMMER 3300 POUNDS VARIABLE GENERALLY 10'	14" DIAM. 11' LONG HEMLOCK BLOCK FITTED 7½" INTO STEEL CAP.	$L = \frac{2WH}{S+1.0}$ ENG. NEWS FORM.	PRACTICALLY NONE			
O	STANDARD	DROP	STEEL CAPS 7' OR 4 LONG CUSHION 2' OR 1' OLD BELTING OAK FOLLOWER		NONE			
P	NO SPECIAL EQUIPMENT.	STEAM HAMMER WEIGHT DROP 5000# 3-6" 3300# 3-0" AND DROP HAMMER WEIGHT DROP 6000# ? 10,000# ? WE FOUND 10000# HAMMER LESS DESTRUCTIVE TO PILES THAN THE 6000# HAMMER	WOOD CUSHION IN BONNET OF THE HAMMER AND A ROPE MAT ON TOP OF THE PILE	BY THE USE OF TEST PILES		GR. LAKES DREDGE & DOCK CO. NONE CUMMINGS 3.5% CHENOWETH NONE	1 IN 3300+ HARD DRIVING MANY HEADS CRUSHED FOR A FOOT OR SO 1.3% 6000# HAMMER, NONE 10000# HAMMER, NONE EASY DRIVING.	NONE NONE NONE NONE
Q	WELLS FOR FORMS BORED WITH AN ORDINARY HAND DRILLING OUTFIT.							
R	STANDARD DRIVER WITH EITHER STEAM OR DROP HAMMER IN SOME CASES JETTING SAVES TIME.	RY. CO. EQUIP. IS SAME AS FOR WOOD PILES 3 TON VULCAN STEAM 85 BLOWS PER MIN	CAST IRON DRIVING CAP ROPE CUSHION	CONDITIONS WERE KNOWN AND PILES WERE DRIVEN TO REFUSAL. WHEN HAVE OCCASION TO USE A FORMULA USE A.W. ZESIGER'S FORMULA.	NONE "	NONE "	NONE "	NONE "

	DO YOU CONSIDER CONCRETE PILES SUITABLE FOR USE IN TRESTLE BENTS WHY ?	UNDER ORDINARY CONDITIONS WHAT LOAD WOULD YOU ALLOW ON A TRESTLE BENT CONCRETE PILE ?	UNDER ORDINARY CONDITIONS WHAT PENETRATION & MAX. PROJECTION ABOVE GROUND WOULD YOU RECOMMEND FOR CONCRETE PILES IN A TRESTLE BENT ?	DO YOU CONSIDER A TAPERED PILE POSSESSES ANY ADVANTAGES OVER A STRAIGHT SIDED PILE ? WHY ?
A				
B	PRE-MOULDED YES DURABLE AND NO MAINTENANCE	ABOUT 25 TONS INCLUDING IMPACT	ABOUT 18' PENETRATION ABOUT 16' PROJECTION	EASIER TO HANDLE IS ECONOMICAL OF MATERIAL & EXCEPT UNDER CERTAIN CONDITION IS LESS LIABLE TO SETTLE
C	YES SOME IN SERVICE 8 YEARS HAVE ABOUT 20 MILES CONC. TRESTLE	20 TONS	15 FT. PENETRATION 14 FT. PROJECTION	NO
D	YES - IN MANY LOCATIONS ARE CHEAPER THAN ANY OTHER BENT	20 TONS	12 TO 14 PENETRATION MAX. PROJECTION OF 20' BASE OF RAIL TO GROUND.	YES PREFERRED ON ACCOUNT OF LESS LIABILITY OF SETTLEMENT.
E	PRE-MOULDED YES	20 TO 25 TONS	CANNOT STATE PENETRATION HAVE DRIVEN SOME 25' FOR HEIGHT ABOVE GROUND WOULD SAY 15 TO 20 FT.	NO
F	YES BECAUSE OF THEIR PERMANENCY.	DEPENDS UPON NATURE OF MATERIAL DRIVEN IN	PENETRATION SHOULD BE 2/3 LENGTH OF PILE IF PILE IS 8 TO 10 FT. ABOVE GROUND.	YES ABILITY TO DRIVE IT
G	PREFER SLIM R'FD PIERS (ON PILES) EXTENDED 1 TO 2 FT. BELOW GROUND SURF.	25 TO 35 TONS PER PILE	PEN. 12' OR OVER WITH PROPER FETCH UP. PREFER SLIM RFD PIERS ABOVE GROUND WITH LONG'T STRUTS ABOVE 20' HIGH	SLIGHT IF ANY STRAIGHT SIDED HAS A DECIDED ADVANTAGE IN MOULDING AS ALL LENGTHS MADE SAME MOULD
H	YES CHEAPER THAN PIERS WHERE FOUND'N PILES ARE NEEDED OR WHERE PIERS>10' HIGH	27 TONS PER PILE 135 TONS PER BENT	25' PENETRATION MAXIMUM 15' " MINIMUM 15' PROJECTION	NO STRAIGHT SIDE PILE USED BECAUSE IT PROVIDES SECTION & REINFORCEMENT SUFFICIENT FOR SAFE HANDLING
J	YES DURABLE AND STRONG. NOT LIABLE TO INJURY IN DRIVING	35 TONS	DRIVE TO REFUSAL IF NOT EXCESSIVE DEPTH. PROJECTION 20 FT. ABOVE GROUND UNSUPPORTED.	LESS WEIGHT SO DRIVE BETTER. COST LESS
K	YES EXCEPTING THE ITEM OF COST.	WOULD NOT MATERIALLY CHANGE LOAD ALLOWED ON WOODEN PILES.	MIN. PENETRATION 10 FT. WE MIGHT ALLOW A 10 FT. PROJECTION WITHOUT BRACING.	YES COMPACTS SURROUNDING MATERIAL TO A GREAT EXTENT. & INCREASES FRICTION THUS BOTH INCREASING CARRYING CAP
L	YES ON ACCOUNT OF THEIR PERMANENCY.	20 TONS	DRIVEN TO A PENETRATION OF 20 FT. WOULD RECOMMEND PROJECTION OF 30 FT.	NO
M	NO EXPERIENCE			IF DRIVEN THROUGH FIRM MATERIAL PREFER TAPERED IF THROUGH SOFT TO REST ON FIRM MAT'L PREFER STR SIDED
N	YES BECAUSE OF DURIBILITY AND ABSENCE OF FIRE RISK.	USE FORMULA DRIVE UNTIL OBTAIN PENET'N NEEDED TO SUPPORT LOAD WITH SAFE FACTOR	PENETRATION DEPENDS ON NATURE OF EARTH. LOAD TO BE SUPPORTED AND FACTOR DESIRED.	NO. DECIDED DISADVANTAGE VALUE OF A PILE DEPENDS ON A LARGE BOT. END DIAM. & SKIN FRICTION ON LARGEST SURFACE
O	YES	STANDARD	DEPENDS UPON CONDITIONS GENERALLY 12' TO 15'	
P	YES IF ECONOMICAL AND SUITABLE BRACING CAN BE APPLIED	HAVE HAD NO EXPERIENCE.	HAVE HAD NO EXPERIENCE	POSSIBLY A SLIGHT ADVANTAGE IN PENETRATION
Q				
R	YES, FOR HEIGHT OF 10 FT. & ABOUT 14 FT SPANS UNDER HEAVY TRAFFIC E 60 LOADING ELIMINATES MAINTENANCE AND DANGER FROM FIRE.	FOR TRESTLE BENT AS PREVIOUSLY DESCRIBED 30 TONS PER PILE INCLUDING 90% OF LIVE LOAD FOR IMPACT.	UNDER HEAVY TRAFFIC 14 FT. SPANS. PROJECTION OF 10 FT. PENETRATION-PILE DRIVEN TO REFUSAL WITH OUR EQUIPMENT	NO FRICTION GREATER ON A UNIFORM PILE THAN ON A TAPERED PILE.

	DESCRIBE FULLY ANY FAILURES THAT HAVE OCCURED.	REMARKS
A		
B	NO FAILURES	WHERE SIMPLEX WERE USED SOIL CONDITIONS PROVE TO BE UNFAVORABLE ESPECIALLY FOR ALIGATOR PT METHOD DETACHABLE C.I PT USED SUCCESSFULLY
C		DESCRIPTION OF PILE TABULATED FROM PLAN FURNISHED WITH REPORT.
D	NO FAILURES	
E	NO FAILURES	DESCRIPTION OF PILE TABULATED FROM PLAN FURNISHED WITH REPORT AND REFERS TO PRE-MOULDED PILE.
F		
G	NO RECORD OF ANY FAILURE	
H	NO FAILURES UNDER TRAFFIC	DESCRIPTION IS FOR 40' PILE THE 8 SHORT LONGITUDINAL RODS USED AT MIDDLE OF LENGTH ARE OMITTED IN THE 20, 25 & 30' PILES.
J		DESCRIPTION REFERS TO PILE MANUFACTURED BY. RY CO. DRAWING № 36 FILE X18 AND NOT TO PILES PURCHASED.
K		
L	NO FAILURES	
M		
N	NOT ANY	IN THE WOOD DRIVING CAP THE GRAIN IS VERTICAL, HEMLOCK WAS FOUND TO BE MOST DURABLE WOOD TABULATED FROM MR. SAMPSON'S REPLY.
O		DESCRIPTION OF PILE TABULATED FROM PLAN FURNISHED WITH REPORT
P	WE HAVE HAD NO FAILURES	THE DESCRIPTIONS GIVEN OF THE OCTAGONAL, RECTANGULAR AND SQUARE PILES REFER TO THE GREAT LAKES DREDGE & DOCK CO. PILES. RY. CO. REPLY STATES PLANS OF THE OTHER PRE-MOULDED TYPES USED ARE NOT AVAILABLE. PLAN FURNISHED SHOWING THE SIMPLEX METHODS.
Q		CONCRETE PLACED BY MEANS OF A BUCKET 18" HIGH 8" OUTSIDE DIAM, TRIP BOTTOM, LID ON TOP, SEPARATE LINE TO TRIP BUCKET.
R	NONE	A FULL STATMENT OF A.W. ZESIGERS FORMULA MAY BE FOUND IN THE CATALOGUE OF THE GREAT LAKES DREDGE & DOCK CO.

APPENDIX A.

American Society of Civil Engineers' list of articles on the manufacture and use of concrete piles, from a search made by the librarian of the Society on Dec. 24, 1914.

(Note:—This is not a complete bibliography but it includes readily accessible material for the year 1908-1914.)

1908.

"Concrete Construction: Methods and Cost," p. 151; by Halbert P. Gillette and Charles S. Hill, N. Y., Myron C. Clark Pub. Co. (Full illustrated article dealing with methods and cost of concrete pile construction for foundations.)

"Concrete Pile Foundations," by M. Deutsch. Industrial Magazine, v. 8, p. 185. (March, 4 pages.)

"Concrete Pile Foundations to a Heavy Reinforced Concrete Warehouse," by Charles R. Coats. Eng. News, v. 59, p. 611 (June 4). (The Raymond Concrete pile was used; ½ page.)

"Concrete Pile Foundations for a Paris Railway Bridge," Eng. News, v. 60, p. 92 (July 23). (Details of octagonal reinforced concrete piles for a railway bridge at Asnières, France; 1 page, illustrated.)

"Concrete Piles," by Stewart G. Collins. Engineers' Society, University of Minnesota. Yearbook, v. 16, p. 65. (Illustrated article with arguments in favor of the use of the concrete pile, also its disadvantages.)

"Concrete Piles Cheaper than Wood," Industrial Magazine, v. 8, p. 140 (Feb.). (Compares the cost of wooden piles and Raymond concrete piles; ½ col.)

"The French 'Compressol' Method of Foundation Construction," by Frank C. Perkins. Industrial Magazine, v. 8, p. 10 (Jan.). (2½ pages, illustrated.)

"Harbor Engineering," p. 61, 72; by Brysson Cunningham. Phil., 1908. J. B. Lippincott Co. (Short passages dealing with materials of which piles are made, their destructibility and preservation.)

"Making, Jetting and Driving Corrugated Concrete Piles," p. 73; by F. B. Gilbreth. Engineering News Pub. Co. (Clear rules, instructions and plans.)

"Notice sur 1 'Exécution des Fondations des Batiments de la Gare du Grau du Roi sur Pilotis Simplex (Ligne d'Aiges-Mortes au Grau du Roi)," by Colombaud. Revue Générale des Chemins de Fer et des Tramways, v. 31, Pt. 2, p. 133 (Sept.). (Details of the use of Simplex piles in railway station buildings in France; 16 pages, illustrated.)

"Recent Development in Pneumatic Foundations for Building," by D. A. Usina, Trans. Am. Soc. C. E., v. 61, p. 218 (Paper 1081, Dec.). (Contains a brief reference to concrete piles.)

"Reinforced Concrete as a Substitute for Wooden Piles and Cross Ties or Sleepers," by Alexander Crawford Chenowith. Proceedings, New York Railroad Club, v. 18, p. 1115 (June). (10 pages, illustrated.)

"Shop-Made Reinforced-Concrete Piles," by L. J. Mensch. Eng. News, v. 60, p. 620 (Dec.). (The piles were cast horizontally and driven by a steam hammer. They were made by L. T. Mensch of San Francisco; 1 page.)

"Special Foundations for a New Edison Sub-Station." Eng. Rec., v. 57, p. 425 (April 4). (Method of driving concrete piles, with combined water jet and pneumatic hammer; 1 page.)

"Spirally Armoured Concrete Piles." Engineer, v. 105, p. 476 (May 8). (On the Considere concrete pile used in Europe; 1¼ pages.)

"When and How Piling Should Be Used in Foundations," by W. M. Brott. Industrial Magazine, v. 8, p. 746 (Oct.). (Describes the Raymond

and Simplex Concrete piling, the loads applied and methods of driving; 10½ pages, illustrated.)

Abstract of same. Cement and Engineering News, v. 21, p. 44 (Feb.). (4 pages, illustrated.)

1909.

" Concrete Piles," by H. J. Cole. Engineering Review (London). v. 21, p. 296 (Nov.). (8½ pages, illustrated.)

" Concrete Foundation Piles—Types, Uses and Advantages," v. 13-14, p. 19; by H. L. Garner. Wisconsin Engineer (Dec.). (Illustrated full article giving details of types and uses, also the comparative cost of wood and concrete piles.)

" Form zur Herstellung von Blechrohrbeton pfählen," by Th. Janssen. Zentralblatt der Bauverwaltung, v. 29, p. 164 (March 24). (Specifications for patent for a metal point for a reinforced concrete pile; 1 par.)

" Concrete Pier Construction on the Pacific Coast, the New Reinforced-Concrete Wharf at Santa Monica," by H. H. Dunn. Cassier's Magazine, v. 37, p. 41 (Nov.). (6½ pages, illustrated.)

" Concrete Piles used in the Steamship Terminals at Brunswick, Ga., and in the Navy Yard Pier at Charleston, S. C.," by M. M. Cannon. Journal of the Association of Engineering Societies, v. 42, p. 24 (Jan.). (Data on making and driving reinforced concrete piles and sheet piles; 11½ pages of text and 6 full-page illustrations.)

Abstract of same. Engr. News, v. 61, p. 549 (May 20). (1¼ pages.)

" Concrete Pile Foundations, with Reference to the 'Simplex' Method of Constructing the Same," by Alexander Melville. Institution of Engineers and Shipbuilders in Scotland, v. 53, p. 97 (1909-10). Edw. H. Parker, Sec'y, 39 Elmbank Crescent, Glasgow, Scotland. (46 pages, illustrated.)

" Reinforced-Concrete Trestles with Pile Bents and Girder Slab Spans; Chicago, Burlington & Quincy R. R." Eng. News, v. 61, p. 546 (May 20). (The concrete piles used are of two forms, rectangular cast piles and Chenowith rolled piles; 2 pages, illustrated.)

" Large Concrete Piles," by Wm. F. Johnston. Eng. Rec., v. 60, p. 362 (Sept. 25). (Describes the compressed pile and its use in Europe; 1¼ pages, illustrated.)

" Pfahl mit gelenkig drehbaren Ankerplatten." Zentralblatt der Bauverwaltung, v. 29, p. 151 (March 17). (Describes a patent for reinforced concrete piles; ½ col. illustrated.)

" Gründung des neuen Regierungsgebäudes in Düsseldorf auf Eisenbetonpfählen," by E. Voss. Zentralblatt der Bauverwaltung, v. 29, p. 482 (Sept. 11). (The use of reinforced concrete piles in a German government building; 3 pages, illustrated.)

Abstract of same. " Reinforced Concrete Piles for a German Government Building," Eng. Rec., v. 60, p. 656 (Dec. 11).

" Gründung des Kühlhauses beim Neubau des Dresdener Schlacht— und Viehhofes im Ostragehege mit Eisenbetonpfählen," by Th. Gesztessy. Beton und Eisen, v. 8, p. 255 (Sept. 1). (Foundation of an abattoir and stockyard at Dresden, with reinforced concrete piles; 2 pages, illustrated.)

" Concrete Piles, Forms, Advantages and Cost as Compared with Wooden Piles," by C. W. Gaylord. Proceedings, National Association of Cement Users, v. 5, p. 300 (20 pages, illustrated.)

" Concrete Piles," by J. F. Springer. Cassier's Magazine, v. 36, p. 426, 505 (Sept. Oct.). (Foundations upon corrugated and molded piles and different methods of driving piles; 27 pages, illustrated.)

" Concrete Piles Dike on the Missouri River, Elwood, Kans." Eng. News, v. 61, p. 177 (Feb. 18). (½ page, illustrated.)

" The Foundations of the Paris, Illinois, Post Office." Eng. Rec.

v. 60, p. 689 (Dec. 18). (Methods of driving pedestal piles for a foundation in Paris, Ill.)

"Eisenbetonpfähle." Beton und Eisen, v. 8, p. 139 (April 23). (On reinforced concrete piles used for the power station of the Pacific Gas and Electric Company at Oakland, Cal.; 1 page, illustrated.)

"Effective Driving of Cast Concrete Piles (Letter)," by L. J. Hotchkiss. Eng. News, v. 61, p. 300 (March 28). (½ col.)

"Discussion of Various Piles and Methods of Driving Them," by Frederic W. Swain. Harvard Engineering Journal, v. 8, p. 288 (April). (Contains 5 pages on making concrete piles and driving them.)

"Concrete Piles with Enlarged Bases," by Hunley Abbott. Eng. News, v. 62, p. 684 (Dec. 16). (½ page, illustrated.)

"Built-Up Concrete Slab Piles and Pile Protection." Eng. Rec., v. 59, p. 601 (May 8). (On the use of slab piles in wharf construction in England; 2 pages, illustrated.)

"Eine ausgeführte Gründung mit Beton-Blechrohr-Phäflen," by Richard Kafka. Zeitschrift des Österr. Ingenieur-und Architekten-Vereines, v. 61, p. 236 (April 9). (3½ pages, illustrated.)

"Betonpfähle Patent Strauss," by W. Gehler. Berlin, Wilhelm Ernst & Sohn. 3 Marks. (A new system of reinforced concrete piles; 44 pages.)

"Betonpfähle System 'Strauss,'" Zeitschrift des Österr. Ingenieur-und Architekten-Vereines, v. 61, p. 788 (Dec. 3). (Describes the Strauss pile; 1 col., illustrated.)

"The Reinforced Concrete Foundation of the New York and Richmond Gas Co.'s New Gas Holder at Clifton, Staten Island," by R. P. Painsford, Industrial Magazine, v. 9, p. 446 (July). (The Raymond Concrete pile was used; 2 pages.)

"A Concrete Pile With Concrete Shell and Removable Steel Core." Eng. News, v. 62, p. 685 (Dec. 16). (½ column.)

"The Reinforced-Concrete Municipal Pier, Santa Monica, Cal.," by Edwin Hall Warner, Eng. News, v. 62, p. 633 (Dec. 9). (Gives details of concrete piling; illustrated.)

"Concrete Piles," by Howard J. Cole, Transactions, American Society of Civil Engineers, v. 65, p. 467 (Dec.). (47 pages, illustrated.)

"Notes upon Docks and Harbors," by Luther Wagner. Trans. Am. Soc. C. E., v. 62, p. 139, 143, 153 (March). (Contains 3 pages on the use of concrete piles.)

"Cast Reinforced Concrete Piles," by Sanford E. Thompson and Benjamin Fox. Jour. Assoc. Eng. Soc., v. 42, p. 1 (Jan.). (Description of the design, construction, and data on driving cast reinforced concrete piles for a foundation of the Boston Woven Hose and Rubber Co.'s power plant in Cambridge, Mass., 17 pages, illustrated.)

Abstract of same. Engineering Record, v. 59, p. 357 (March 27). (2½ pages.)

"The Simplex Pile Foundations for the Grau du Roi Station," by Colombaud. Minutes, Proceedings Institution of Civil Engineers, v. 176, p. 365 (1908-09, Pt. 2.)

1910.

"Concrete Pile Foundations for the Evansville Filters," by F. H. Stephenson. Engineering Record, v. 61, p. 218 (Feb. 19). (Molded concrete piles were used, the points were to go 20 ft. below low water, the piles were placed with a water jet and a 3,000 lb. hammer, 1 page, illustrated.)

"The Reinforced Concrete Wharf of the United Fruit Company at Bocas del Toro, Panama," by Howard T. Barnes. Trans. Am. Soc. C. E., v. 66, p. 289, 294 (March). (Contains details of making concrete piles.)

"Failure of Concrete Piles under Ocean Pier at Long Beach, Cal.," by L. A. Waterbury. Eng. News, v. 64, p. 67 (July 21). (1 col.)

Editorial on same. Eng. News, v. 64, p. 78 (July 21).

"Pfähl gründung für das Palacky-Monument in Prag." Beton und Eisen, v. 9, p. 132 (April 5). (Reinforced concrete pile foundation for a monument at Prague; 1 page, illustrated.)

"Laying Concrete under Water (Letter)," by J. S. Armstrong, Eng. News, v. 64, p. 131 (Aug. 4). (Comments on the failure of a pier at Long Beach.)

"Die Gründung der Neuen Rheinspeicher am Agrippina-Ufer der Stadt Cöln mit Streckmetallumschnürten Eisenbetonpfählen," by Reinken. Deutsche Bauzeitung, Mitteilungen über Zement Beton-und Eisenbetonbau, No. 4, p. 13, 17. (Describes use of reinforced concrete piles for a foundation in the city of Cologne.)

"Interlocking Steel and Concrete Pile Construction for Seawalls and Foundation Work." Eng. News, v. 63, p. 117 (Feb. 3). (Describes piles patented by Henry W. Schlueter; 1 page, illustrated.)

"Ein neues Betonpfählgründungsverfahren," by Joannini. Beton und Eisen, v. 9, p. 161 (April 23). (Describes the Mast System of Reinforced Concrete Piling; 2 pages, illustrated.)

"Reinforced Concrete Pile," by Edw. Mohun. Can. Engr., v. 19, p. 675 (Dec. 1). (Description of method of reinforcing moulded concrete piles by the use of angles in connection with expanded metal; 2 pages, illustrated.)

"Der Konus-Betonpfahl (Patent Stern)," by Beton und Eisen, v. 9, p. 52 (Jan. 28). (Describes the Konus reinforced concrete pile; 1 page, illustrated.)

"Eine Betonfahlgründung nach System Janssen," Deutsche Bauzeitung, Mitteilungen uber Zement, Beton-und Eisenbetonbau, No. 4, p. 16. (On the use of reinforced concrete piles of the Janssen system in the extension of the slaughterhouse at Tilsit; 1 par.)

"Method of Drawing Casing in Concrete Piles with Enlarged Bases (Letter)," by Hunley Abbott. Eng. News, v. 63, p. 19 (Jan. 6). (1 par.)

"Betonpfähle mit Fussverbreiterung." Beton und Eisen, v. 9, p. 64 (Feb. 20). (½ page, illustrated.)

"Gründungen mittels mechanischer Bodenverdichtung 'System Compressol' in Aegypten," by Walther Stross. Beton und Eisen, v. 9, p. 93 (March 14). (Foundations in Egypt by the Compressol system; 2 pages, illustrated.)

"Test of Concrete Piles." Eng. Rec., v. 62, p. 715 (Dec. 17). (Describes test of a pedestal pile; ½ column.)

"Method of Jetting Down Concrete Piles and Records of Output." Engineering-Contracting, v. 34, p. 228 (Sept. 14). (On laying reinforced concrete piles for a boardwalk at Atlantic City, New Jersey; 1 page.)

"Concrete Piles," by Fred J. Biele. Cornell Civil Engineer, v. 18, p. 298 (May). (A brief general description of the Raymond, Simplex, Corrugated, Hennebique, Chenowith and other concrete piles; 8½ pages, illustrated.)

"The Use of Concrete Piles," by Wm. F. Hall. Journal of the Franklin Institute, v. 169, p. 1 (Jan.). (21½ pages, illustrated.)

"Reinforced Concrete Trestles for Railways," by C. H. Cartlidge. Journal of the Western Society of Engineers, v. 15, p. 543 (Oct.). (Gives details of the manufacture and tests of concrete piles; 28 pages, illustrated.)

Abstract of same. "Driving Concrete Piles." Eng. News, v. 63, p. 623 (May 26). (1 par.)

"Concrete Piles," Report of Committee on Masonry, American Railway Engineering and Maintenance of Way Association. Eng. News, v. 63, p. 411 (April 7). (Gives classes of concrete piles, estimated commercial use, advantages and disadvantages of concrete piles.)

"Embedded Wood in Concrete (Letter)," by C. G. Rupert. Eng. News, v. 64, p. 155 (Aug. 11). (On construction of piles for a pier at Long Beach, Cal.; 1 par.)

"Further Light on the Failure of the Long Beach Pier (Letter)," by Mayberry V. Parker. Eng. News, v. 64, p. 185 (Aug. 18). (½ column.)

"Concrete Piles." Proceedings, American Railway Engineering and Maintenance of Way Ass'n, v. 11, Pt. 1, p. 204. (11 pages, illustrated.)

Abstract of same. Eng. News, v. 63, p. 411 (April 7). (1 page.)

1911.

"The Making and Driving of Reinforced Concrete Piles," by Gower Bouverie Raynor Pimm. Minutes, Proceedings Institution of Civil Engineers, v. 189, p. 314 (1911-12, Pt. 3). (5 pages, illustrated.)

"A Comparison of the Initial Cost of Concrete and Wood Piling," by Philip J. Kealy. Engrg.-Cont'g, v. 35, p. 97 (Jan. 25). (1 page.)

"A Concrete Pile Yard." Eng. Rec., v. 64, p. 308 (Sept. 9). (On concrete piling made for the municipal wharf at Oakland, Cal.; 1 par.)

"A Novel System of Concrete Reinforcement." Eng. News, v. 65, p. 292 (March 9). (The application of the Lewen system, extensively used in South America, for reinforcing concrete poles or piles; 1 col., illustrated.)

"Driving Concrete Piles with a 12,000-Pound Hammer." Eng. Rec., v. 64, p. 763 (Dec. 30). (The columns of the reinforced concrete warehouse of the Aling and Corey Paper Company, Pittsburg, have concrete footings supported on 940 reinforced concrete piles, arranged in clusters of 9 to 15.)

"Concrete Pile Driving Practice on the Burlington Railroad," by L. J. Hotchkiss. Eng. Rec., v. 64, p. 258 (Aug. 26). (The concrete piles are of two kinds,—the rolled or Chenowith pile and a square pile cast in wooden moulds,—details of driving piles are given; 1 page, illustrated.)

Editorial on same. Eng. Rec., v. 64, p. 235 (Aug. 26).

"Concrete Pile Foundations in Drilled Holes." Eng. News, v. 65, p. 165 (Feb. 9). (Holes were drilled into the rock and concrete piles were cast into these holes.)

"Cost of Manufacturing Concrete Piles on the Panama Canal." Eng. News, v. 66, p. 301 (Sept. 7). (1 par.)

1912.

"Strausspfahlgründungen in der Schweiz," by Kersten. Schweizerische Bauzeitung, v. 59, p. 263 (May 18). (An account of some of the constructions built upon the Strauss patented knobby concrete piles; 5 pages, illustrated.)

"Concrete Pile Footings for the 42-Story L. C. Smith Bldg., Seattle, Wash." Engineering News, v. 68, p. 914 (Nov. 14). (The piles used in the work were of the filled shell type patented by the Raymond Concrete Pile Co.; describes method of driving piles. 2½ pages, illustrated.)

"Damplanken van gewapend Beton," by W. Lammers. De Ingenieur, v. 27, p. 1013 (Dec. 14). (On concrete sheet piling, 3 pages, illustrated.)

"Concrete Piles and Concrete Piling Equipment," by Maxwell M. Upson. Cement and Engineering News, v. 24, p. 351 (Dec.). (12½ pages, illustrated.)

"The Scantlings of Reinforced-Concrete Piles," by Frank H. Jeffree. Engineering (London), v. 93, p. 337 (March 15). (1⅓ pages, illustrated.)

"Concrete Piles and Concrete Piling Equipment," by Maxwell M. Upson. Journal, American Society of Engineering Contractors, v. 4, p. 203. (45 pages of description and 29 full-page illustrations.)

Abstract of same. "Concrete Piles." Railway Age Gazette, v. 53, p. 53 (July 12). (3 pages.)

- "Concrete Piles and Concrete Piling Equipment," by M. M. Upson. Cement Engineering News, v. 24, p. 351. (Long illustrated article on types of piles, tests to determine carrying capacity, and information concerning sheet piling.)

1913.

" Large Concrete Pile Installation, Data on Preliminary Bearing Tests and Details of Driving More than 11,000 Cast-in-Place Piles for Steel Plant Foundations." Eng. Rec., v. 67, p. 36 (Jan. 11). (The piles were driven by the Raymond Concrete Pile Co.; 1½ pages, illustrated.)

" 'Simplex' Concrete Piles at Alost Station, Belgium." Railway Engineer, v. 34, p. 73 (March). (2 pages, illustrated.)

" Some Experiences with Concrete Piles in Chicago," by J. Norman Jensen. Engineering News, v. 69, p. 416 (Feb. 27). (2 pages, illustrated.)

" Protecting piles against Teredos and Limnoria," by O. P. Shelley. Concrete-Cement Age, v. 2, p. 152 (March). (Describes a system of coating a wooden pile for a length to reach from below the mud-line to high water with a cement mortar, applied with the " Cement Gun " over a suitable reinforcement, designed by the author of the article, 1 page, illustrated.)

" Hydraulic Driven Ferro-Concrete Piles and the 'Compressol' System of Solidifying Foundations." Ry. Engr., v. 34, p. 215 (July). (3 pages, illustrated.)

" Concrete Pile Specifications for the Point Bridge at Pittsburgh." Eng. Rec., v. 68, p. 581 (Nov. 22). (Illustrated, gives method of construction and installation, loading tests, settlement and capacity.)

" Large Concrete Pile Installation for Youngstown Sheet and Tube Co.'s Steel Plant." Eng. Rec., v. 67, p. 36-37 (Jan. 11). (Data on preliminary bearing tests and details of driving more than 11,000 cast-in-place piles for steel plant foundations.)

" Inspection of Concrete Construction," p. 555, by Jerome Cochran. Myron C. Clark Pub. Co., 13 Park Row. (Clear chapter on inspection of molding, and driving concrete piles.)

" Construction Problems, Dumbarton Bridge, Central California Railway," by E. J. Schneider. Trans. of the Amer. Soc. of Civ. Engrs., v. 76, p. 1572. (Long, full article with diagrams and illustrations giving details as to driving of piles.)

" Imperfect Concrete Piles," by Francis L. Pruyn. Eng. Rec., v. 67, p. 328 (March 22). (Results of tests of special concrete piles; 1 page, illustrated.)

" Cast-in-Place Concrete Piles (Letter)," by Irwin & Witherow. Eng. Rec., v. 67, p. 591 (May 31). (Comments on tests of piles, discussed in F. L. Pruyn's article.)

" Reinforced-Concrete Piles on the Chicago, Rock Island & Pacific Ry." Engr. Rec., v. 67, p. 606 (May 31). (1 col., illustrated.)

" Concrete Pile Specifications." Eng. Rec., v. 68, p. 581 (Nov. 22). (Method of construction and installation, loading tests, settlement and capacity; ½ page.)

" Aids to Navigation on the Missouri River, Concrete Piles Employed in Dam Construction," by Frank C. Perkins. Scientific American Supplement, v. 75, p. 100 (Feb. 15). (1 page, illustrated.)

1914.

" Precast Concrete Pile." Eng. News, v. 71, p. 1431-2 (June 25). (A few remarks on its usefulness.)

" Reinforced Concrete Piles Ninety-one feet long, for Pier 35, at San Francisco." Eng. Rec., v. 69, p. 736 (June 27). (Full particulars as to dimensions and weight—1 col.)

" Special Concrete Piling for a Viaduct Foundation," by J. Stewart. Eng. News, v. 71, p. 1412-4 (June 25). (Gives composition of molded sections, and table of test pile, illustrated.)

" Notes on the Use and Cost of Concrete Pedestal Piles." Concrete Cement, v. 4, p. 31 (Jan.). (Illustrated, gives methods used in pile driving.)

" Reinforced-Concrete Steamship Piers, Havana, Cuba." Eng. News,

v. 71, p. 1397 (June 25). (Describes the reinforced concrete pile used in the pier).

"Standard Concrete Piles for Bridge Foundation." Eng. Rec., v. 69, p. 197 (Feb. 14). (Square reinforced piles and forms adopted by Chicago, Burlington & Quincy, 1 col.)

"Band vs. Spiral Hooping for Concrete Piles (Letter)," by F. H. Frankland. Eng. News., v. 72, p. 37 (July 2). (½ page.)

"Special Concrete Piling for a Viaduct Foundation," by John Stewart. Eng. News, v. 71, p. 1412 (June 25). (Describes a precast pile grouted into a hole made by a previously-driven shell; 2 pages, illustrated.)

Editorial on same. "The Precast Concrete Pile." Eng. News, v. 71, p. 1431 (June 25).

"Large Reinforced-Concrete Pier at Halifax." Eng. Rec., v. 69, p. 662 (June 13). (On the use of 24-in. piles, 75 ft. long, made of special cement to resist chemical action, brace piles cambered to neutralize stresses, details of driving and placing are also given; 3 pages, illustrated.)

"Timber Piles and Drivers; Bearing Power of Piles; Concrete Metal and Sheet Piles," pp. 116, 189, by H. S. Jacoby and R. P. Davis. N. Y. McGraw-Hill Book Pub. Co., 239 West 39th St. (A very full, illustrated article, giving costs.)

"Manufacture of Reinforced Concrete Poles, Piles and Pipe without the use of Forms," p. 26, by R. M. Jones. Nat. Reinf'd Concrete Pole, Pile and Pipe Co., Ideal Bldg., Denver, Colo. (A short illustrated, clear article.)

"Berechnung von Giebelpfeilerfundamenten," by Heinrich Becher. Beton und Eisen, v. 8, p. 301 (Oct. 8). (2 pages, illustrated.)

"Die Gründung des Kühlhauses auf dem Schlachthof in Tilsit," by Th. Janssen. Beton und Eisen, v. 9, p. 165 (May 14). (On the use of reinforced concrete piles for the foundation of a slaughterhouse in Tilsit; 2 pages, illustrated.)

"The Construction of a Concrete Sea-Wall on the Lower Mississippi." Concrete-Cement Age, v. 4, p. 15 (Jan.). (Gives brief details on jetting sheet piles into place; 1 page, illustrated.)

"New Type of Driver for Large Concrete Piles." Eng. Rec., v. 69, p. 612 (May 30). (Equipment specially designed for use in building the reinforced-concrete pier of the Intercolonial Railway at Halifax; 1 page, illustrated.)

"Pile Foundations for Large Railway Shops." Eng. Rec., v. 69, p. 682 (June 13). (Three thousand concrete pedestal piles were used; 1¼ pages, illustrated.)

"Notes on the Use and the Cost of Concrete Pedestal Piles." Concrete-Cement Age, v. 4, p. 31 (Jan.). (1 page, illustrated.)

"'Frankigaoul' Enlarged-Base Reinforced Concrete Piles." Railway Engineer, v. 35, p. 41 (Feb.). (Description of a system of casting concrete-piles having flattened bases; 2 pages, illustrated.)

"Compound Piles of Timber and Ferro-Concrete," by R. Schönhöfer. Surveyor and Municipal and County Engineer, v. 45, p. 324 (Feb. 13). (Describes a pile designed by Michael Heimbach of Austria; 2 pages, illustrated.)

Abstract of same. "Compound Piling, Timber Below, Reinforced Concrete Above and an Effective Coupling," by R. Schoenhoefer. Engineering Magazine, v. 47, p. 279 (May).

"Sinking Concrete Piles by Explosion." Railway Engineer, v. 35, p. 183 (June). (Describes the Wilhelm System of sinking concrete piles; 2½ pages, illustrated.)

Abstract of same. "Enlarged Base Concrete Piles." Industrial Engineering, v. 14, p. 305 (July). (1 col.)

"Concrete Piles with Bulbous Ends Formed by Explosive." Eng. News, v. 72, p. 83 (July 9). (½ page, illustrated.)

"A New Type of Concrete Pile." Eng. News, v. 71, p. 1282 (June 11). (The essential feature of this pile is the grouting of a precast concrete pile into a previously driven concrete tube; 1 page, illustrated.)

"New System of Concrete Piling." The Engineer (London), v. 117, p. 489 (May 1). (Describes the Ridley concrete pile and pile-depressing mechanism; 1 page, illustrated.)

"A New Concrete Piling, Semi-Molded, Semi-Liquid Process Filling all Voids with no Driving." Engineering Magazine, v. 47, p. 594 (July).

"Load-Tests on Concrete Piles, North Side Point Bridge Approach, Pittsburgh." Eng. News, v. 72, p. 310 (Aug. 6). (Tests were made by the Raymond Concrete Pile Co.; 1¼ pages.)

"Heavy Loading Tests of Concrete Piles." Eng. Rec., v. 70, p. 140 (Aug. 1). (Cast-in-place piles driven in filled ground and subjected to 36-hr. 60-ton loads with 3-16 in. average settlement, the piles were for the foundations of the approaches to the North Side Point Bridge, Pittsburgh; ½ page, illustrated.)

"A Reinforced-Concrete Sheet-Pile Sea Wall." Eng. News, v. 71, p. 292 (Feb. 5). (Describes piles being used along the whole water front of the City of Bay St. Louis, Miss.; ½ page, illustrated.)

The Following References Can Not Be Verified as Periodicals Are Not In the Library.

"Siegwart Reinforced Concrete Piles." Concrete and Constructional Engineering, v. 4, No. 6, p. 440 (Description).

"Concrete Piles." Civil Engineering, Vol. 4, No. 9, p. 375. (Their uses in difficult foundation work.)

"Pilotis en Béton Armé," by F. Marre. Cosmos, v. 58, No. 1257, p. 229.

"Les Fondations du Palais du Justice de Paris." Nature, v. 37, No. 1864, p. 164.

1908.

"Best Form for Reinforced Concrete Piles," by R. Kafka. Oest. Wochenschr. f. d. Oeffent. Baudienst, Dec. 19. (Illustrated.)

1909.

"Gründsverfahren mit Betonbohrpiloten System Strauss," by Otto Colberg; Vortrag in der Versammlung 23 Februar, Österreichischer Beton-Verein. Osterr. Wochenschrift öffentlichen Baudienst, No. 13, p. 198.

"Strauss wider Simplex Eisenbeton," by Alfred Berlowitz. Eisenbeton, No. 23, p. 231.

"The Simplex System of Concrete Piling." Practical Engineer, No. 1145, p. 176. (Large tube with toothed jaws forming point and capable of opening automatically while concrete is deposited simultaneously with the pulling.)

"Betonfundierung mittels des Simplex-Betonpfählsystems." Baugewerks-Zeitung, No. 96, p. 993.

"Betonpfähle nach dem Simplex-System," by Oe. Betonzeitung, No. 39, p. 719.

"Belastungsproben mit Simplex-Betonpfählen," by H. Buchartz. Armierter Beton, No. 3, p. 127. (Results of investigation by Köhncke & Co. of Simplex piles in Hamburg.)

"Die Simplexbetonpfählgründung. Mitt. Ing. öst. Staatsbahnen, No. 11, p. 131.

"Kritische Betrachtung der Simplex-Betonpfählgründung," by Schmid. Betonzeitung, No. 6-7, p. 105, 125.

"Eiserne Mantelform fur Simplex-Betonpfähle." Zement und Beton, No. 6, p. 74.

"Interessante Fundierungen in Paris." Wochenschrift deutscher Bahnmeister, No. 31, p. 573. (The Compressol System.)

"Eisenbetonpfählgründung." Eisenbeton, No. 15, p. 139. (Description of reinforced concrete piles used in foundations in Charlottenberg and Berlin.)

"Betonpfählgründungen beim Neubau des Personenbahnhofs in Karlsruhe," by Ammann. Betonzeitung, No. 35, p. 685.

"Das Einrammen des Gründungspfähle aus Eisenbeton." Ziegel und Zement, No. 8, p. 113.

"Vorrichtung zum Einrammen von Pfählen aus mit Beton gefüllten Tonrohren." Der deutsche Steinbildhauer, No. 23, p. 182.

"Fundamentplatten aus Eisenbeton." Betonzeitung, No. 50, p. 993.

"Betonpfahl mit dünnwandigen Blechrohr." Architekten-Zeitung, Vol. 3.

"Herstellung von Betonpfählen." Betonzeitung, p. 70.

"Betonpfähle mit dünnwandigen Blechrohr." Betonzeitung, No. 45, p. 892.

"Gründungen mittels umschnürter Betonpfähle," by A. Kleinlogel. Profanbau, No. 18, p. 332.

"Eisenbeton gründungsplatte für den Neubau eines Geschäftshauses," by Ramisch. Zement und Beton, No. 2, p. 13.

"Einfache Gründungsarten mittels Eisenbeton," by Pietschmann. Oesterreichische Bahnmeister Zeitung, No. 21, p. 121.

"Die Herstellung der Rammpfähle aus Eisenbeton." Ziegel und Zement, No. 3, p. 33.

"Herstellung von Betonpfählen in der Erde." Osterreiche Bauzeitung, No. 22, p. 132.

"Betonpfähle," by G. Strahl. Betonzeitung, No. 25, p. 487.

"Der Betonpfähl," by A. Speetz. Betonzeitung, No. 28, p. 547.

1910.

"Compressol Foundations." Concrete and Constructional Engineering, vol. 5, p. 755.

"Practical Notes on Making and Driving Reinforced Concrete Piles," by Vere Sussex Hyde. Practical Engineer, Nov. 25. (Practical directions for the work, twenty-five hundred words.)

"Betongründung." Zement und Beton, No. 1, p. 12.

"Gründung mit Betonpfählen." Uhlands technische Rundschau, Augabe, 2, No. 8, p. 60. (Gives examples of the Simplex pile and of the Compressol system.)

"Des Konus-Betonpfahl," by W. Siegfried. Schweizerische Bauzeitung, Oct. 29. (A detailed description of a new system of pile foundation; four thousand words, illustrated.)

"Fundierung mit Pfählen aus Beton und Eisenbeton," by A. Rosler. Zeitschrift fur Tiefbau, v. 6, No. 13, p. 129 (July 1). (Descriptions of the systems "Dulac-Compressol," "Raymond," "Simplex" and Strauss" with illustrations.)

"Fundierung mit Pfählen aus Beton und Eisenbeton," by A. Rosler; Zietschrift fur Tiefbau, v. 6, No. 11, p. 113.

"Form zur Herstellung von Blechrohrbetonpfählen." Betonzeitung, No. 13, p. 262.

"Herstellung von Betonpfählen." Kunstein-Industrie, No. 3, p. 59.

"A Review of the Use of Concrete Piles in America." Concrete, No. 5, p. 42.

"Eisenbetonpfähle." Zement und Beton, No. 21, p. 320.

1911.

"Noueau Système de Pieux Armés," by P. Beaumont. Revue Industrielle, Nov. 18. (Description of concrete pilings with metal cores; 2,000 words, illustrated.)

1912.

"I pali per fondazione." Il Cemento, Nov. 15 (Serial). (Types of reinforced concrete piling, describing especially the Conus type; illustrated.)

1913.

"Concrete Socket Piling," by K. D. MacLean. Western Engineering, August. (Describes pier substructure construction, especially the concrete piles, giving tests.)

"Concrete Piles for Strengthening Foundations." Iron Trade Review, v. 53, p. 681 (Oct. 16). (Illustrated.)

1914.

"The Heimbach System of Combined Wood and Reinforced-Concrete Piles and the Lengthening Wooden Piles," by Schoenhoefer. Concrete and Constructional Engineering (March).

"Fondations en Terrains Compressibles per Pieux Explosés," by P. Beaumont. Revue Industrielle, March 21. (Experiments with concrete piling wherein the base has been enlarged with an explosive before the concrete has set; illustrated.)

CONCRETE CULVERT PIPE.

Upon checking over the replies received to the circular list of questions it developed that the following roads have not used concrete culvert pipe at all or to such a limited extent only that they feel that the results of their slight experiences are not of sufficient interest to be considered by the committee:

Algoma Central & Hudson Bay.
Atlantic Coast Line.
Boston and Albany.
Boston and Maine.
Central of Georgia.
Central of New Jersey.
Central Vermont.
Chicago, Terre Haute and Southeastern.
Colorado Midland.
Delaware and Hudson.
Detroit, Toledo and Ironton.
El Paso and Southwestern.
Florida East Coast.
Gulf, Colorado and Santa Fe.
Georgia Southern & Florida.
Hocking Valley.
International and Great Northern.
Lehigh Valley.
Louisville & Nashville.
Missouri, Kansas & Texas.
Missouri Pacific.
New Orleans, Mobile & Chicago.
New York Central lines, east of Buffalo.
Norfolk Southern.
Pere Marquette.
Philadelphia & Reading.
Pittsburg, Shawmut & Northern.
Rutland.
Seaboard Air Line.
Toledo, St. Louis & Western.
Union Pacific.
Vandalia.
Wheeling & Lake Erie.

The use of concrete culvert pipe is much more general among the railroads than that of concrete piles. Consequently the information received by the committee was much greater and the resulting tabulations considerably larger than in the case of the concrete piles.

Referring to the tabulation concerning the use of concrete culvert pipe it is seen that while some of the roads have used this pipe in special instances, or for experimental purposes only, quite a number use the pipe generally for sizes ranging from 24 in. to 48 in. internal diameter inclusive. A few make common use of sizes varying from 12 in. to 72 in. inclusive while at least one uses as large as 84 in. x 89 in. oval pipe.

It is not the general practice to restrict the heights of embankments under which concrete pipe is used, other than to specify a certain minimum depth of cover over the pipe which minimum varies from 8 in. between the bottom of tie and the top of the pipe to about 3 ft. from the base of rail to the top of the pipe. The road reporting the 8 in. minimum stated that its only reason for not placing pipe closer than 8 in. to the tie is that a less distance than this does not afford sufficient protection to the pipe from injury from tamping tools. There is involved in this discussion of the restriction of the heights of embankments, of course, the general question of the appropriateness of placing a rather small pipe under a very high fill even though the drainage requirements are satisfied. Some roads do not place pipe culverts of small diameter under extremely high fills irrespective of the fact that their carrying capacity is ample to take care of the expected quantity of water.

It is not the usual practice to have two or more designs of concrete pipe of the same diameter with differing amounts of reinforcement and thickness of the walls for use under different heights of embankments. The Chicago, Rock Island and Pacific, however, does make such a distinction, having a design known as Class " B " for embankments up to 20 ft. in height and another known as Class " C " for embankments from 20 to 40 ft. high. The amount of reinforcement and the thickness of the walls are both increased in the class " C " design.

Two of the photographs are inserted for the purpose of showing reinforced concrete culvert pipe in actual service under rather extreme conditions; the first mentioned shows two lines of 60 in. pipe with only 2 ft. of cover and the second two lines of 60 in. pipe under a 70 ft. fill.

In 1906 Prof. Arthur N. Talbot of the University of Illinois tested to destruction several sections of 48 in. and 36 in. reinforced concrete culvert pipe. The results of these tests, which were made under laboratory conditions of bedding and loading are recorded in bulletin No. 22 of the University of Illinois.

The average of the results of these tests for distributed load shows that the first fine cracks appeared at a load of about 1860 lb. per sq. ft.; that what Prof. Talbot calls the critical load averaged about 3,400 lb. per sq. ft., and that the average maximum crushing load was about 6,130 lb. per sq. ft. The report states that by first cracks are meant the very fine cracks that were first observed and which resemble those formed in reinforced concrete beams but which do not detract from the strength or wearing qualities of the structure. The critical load is the load at about the point where the deflection shows a marked increase and it is at approximately this point that there is considerable change in the pipe as evidenced by the enlarging of the tension cracks or by shear cracks forming. Prof. Talbot states that "after the critical load has been passed the reinforced concrete ring will, under the conditions of the test, bear a considerably higher load than the critical load, though it must be understood that this load comes after the reinforcement has ceased to act as in a reinforced concrete beam, that the cracks formed are such that the reinforcement may be exposed and the durability of the structure threatened, and that the strength of the pipe is dependent upon the maintenance of the lateral restraint of the sand at the sides."

The actual pressures on pipe in service under embankments of different heights is of course unknown and the assumptions of engineers in making computations for the strength of pipe vary considerably. Take for instance, the rather extreme cases of two culverts, one having a fill of only 2 ft. over it, and the other a fill of 70 ft., the material composing the embankments, weighing 100 lb. per cu. ft., and assuming a live load equivalent to Cooper's E. 60, with 50 per cent impact in the case of the 2 ft. fill and no impact in the other. Assume also that the dead load is transmitted directly to the pipe and the live load is transmitted vertically along the track and at slopes of ½ to 1 across the track from the ends of an 8 ft. tie. For the portion of the pipe under the 8-ft. tie the pressures per sq. ft. for the 2-ft. and 70-ft. fills will be about 2,000 and 7,150 lb. per sq. ft. respectively.

These loads are seen to be in excess of those obtained in the above tests. The tabulation and the photographs disclose the fact, however, that reinforced concrete culvert pipes are actually giving good service under just such heights of embankments. This goes to show that the pipes do not in fact receive anywhere near the above calculated loads but that a large share of the weight is taken care of in some other manner, probably by the natural arch of earth which may be formed over the pipes.

In the bulletin above referred to Prof. Talbot recommends the following formula for the design of reinforced concrete pipe:

$M = 1\text{-}16\ W\ d$ for a uniformly distributed load over the horizontal section and with no side restraint.

$M = 0.159\ Q\ d$ for a concentrated load at the crown.

$M_o = 0.87\ A\ f\ t$ for the resisting moment of the pipe section acting as a reinforced concrete beam.

In the above formulae

M=Bending moment in inch-pounds,

Mo=Resisting moment in inch-pounds,

W=Total load in pounds per lineal foot of pipe,

d=Mean horizontal diameter of pipe,

A=Area in square inches of steel reinforcement per foot of pipe, to give the ultimate breaking load at the yield point of steel.

f=Strength of the steel reinforcement at the yield point, the value of which is often used at 5,500 lb. per sq. inch.

t=Distance from the center of the reinforcement to the compression face of the concrete.

Q=The concentrated load in pounds applied at the crown.

These formulae are in general use among railway engineers and the engineers of the manufacturers of reinforced concrete pipe.

The Chicago, Milwaukee and St. Paul uses these formulae with the following working stresses:—

Concrete, compression in extreme fiber	700 lb. per sq. in.
Steel, in tension	16,000 " " " "

and designs so that by using the above formula for distributed load, the safe load for all sizes of its standard pipe figures out at 2,000 lb. per sq. ft. This road considers that the load of 2,000 lb. per sq. ft. corresponds approximately to the total live and dead load pressures under low fills and that for higher fills the greater spread of the live load and the arch action of the fill keep the maximum pressure per square foot well within this limit.

The maximum safe concentrated loads that can be carried by the several sizes of reinforced concrete pipe of this road are given by this company, using the formula:—

$M=0.159\ Q\ d$, as follows,

20 in.	pipe	1,500 lb.	36 in.	pipe	2,800 lb.
24 "	"	1,700 "	42 "	"	3,200 "
30 "	"	2,300 "	48 "	"	3,600 "

Some manufacturers of reinforced concrete pipe which is in general use and giving good service design practically all sizes for the uniformly distributed load of 1,250 lb. per sq. ft. of horizontal projection.

For the members of the association who may not have had time to go into the details of how reinforced concrete pipe is designed but who are nevertheless interested, the following example is worked out in accordance with a method that is in common use by the engineer of one of the manufacturers of reinforced concrete pipe.

PROBLEM: Design a 36-in. culvert pipe for a uniform load of 1,250 lb. per sq. ft. It will be necessary to assume a thickness for the ring and determine the stress and the reinforcement required. We will assume a thickness of 4 in. which will give us a mean diameter "D" of 3.33 ft.

We will determine the stresses at the critical points at the center of the top and of the bottom on the assumption that the vertical pressure on the upper and lower half are equal and that no side pressure is exerted. We will consider a section of pipe one foot long. The following notation will be used in this problem:

Ma=Bending moment in inch-pounds.

Mc=Resisting moment as governed by concrete.

$f\ c$=Unit stress in concrete, taken out at the rather high value of 750 lb. per square inch.

$f\ s$=Unit stress in steel taken at the usual value of 16,000 lb. per square inch.

W=Load in pounds per square foot.

A=Area of steel required.

D= Mean diameter.

d=Distance from the reinforcement to the compressive face of the concrete.

t=Thickness of pipe=d plus 1 in.

b=Length of section under consideration=12 in.

Ms=Resisting moment as governed bv the steel.

The formulae $Ma=1\text{-}16\ W\ D$ where W is the total uniform load per lineal foot of pipe becomes $Ma=1\text{-}16\ W\ D^2$ when W is the load per square foot.

Inserting our values in this formula.

$Ma=1\text{-}16\times1250\times(3.33)^2=865.5$ foot-pounds

$Ma=10{,}386$ inch-pounds

$$Mc=1\text{-}6\ b\ d^2\ f\ c$$

$$Mc=1\text{-}6\times 12\times 750\ d^2 \qquad d^2=\frac{Mc}{1{,}500}$$

d=the square root of the quantity 10,386 divided by 1,500=2.62 in
t=d plus 1 in.=3⅝ in.

$$Ms=\tfrac{7}{8}\ d\ A\ f\ s$$

$$Ms=\tfrac{7}{8}\ d\ A\ 16{,}000 \qquad A=\frac{Ms}{\tfrac{7}{8}\times 16{,}000d}=\frac{Ms}{14{,}000d}$$

$$A=\frac{10{,}386}{14{,}000\times 2.62}=0.28 \text{ sq. in.}$$

Use ⅜ in. round bars on 4½ in. centers which give 0.29 sq. in.

In this manner we find that for this particular problem we requir walls at least 3⅝ in. thick, reinforced with ⅜ in. round bars on 4½ ir centers.

The longitudinal rods that are usually inserted are merely to spac the transverse rods and hold them rigid. These longitudinal rods ca be placed at the discretion of the designer. The reinforcement should b placed, of course, so as to be nearer the inside face of the wall at th top and bottom of the pipe and nearer the outside wall at the sides c the pipe because it is at these places that the greatest tension occur.

The tabulation of the replies to the circular letter concerning the us of concrete culvert pipe together with the reproduction of the drawing which are included in this report shows the characteristics and method of reinforcement of the pipe so much in detail that it is unnecessary t make any comments.

More roads use head walls on one or both ends of the concrete pip culverts than do not use them. The bell and spigot continues to be th more popular type of joint while the roads are pretty evenly divided o the question of cementing the joints. All of the joints, no matter of wh type or whether cemented or not seem to be pretty uniformly satisfa tory, except that one road that has purchased some non-reinforced dr mix pipe states that while many bells were broken in handling very li tle trouble was experienced after placing the pipe. This road makes i own reinforced pipe and has had no trouble with the joints. One oth road purchased concrete pipe for one opening only and found that it d not fit together very well and had to be chipped.

Of the railroads answering our questions 25 purchase their pi made either to their own design or accept the manufacturers' standar 6 make their own pipe, while 4 purchase some and manufacture so themselves.

The length of time the pipe should cure before shipping shows very considerable variation ranging in air from 10 days to 60 days whi some roads do not install pipe that is less than 90 days old although th ship after pipe has cured 60 days.

Considerable space has been devoted in the tabulation of the que tion of failures of pipe in place and to the breaking of pipe in handlin While there have been a few failures of pipe in place and a considerab number have been broken in handling it is seen in reading over t replies that many of these are due either to poor concrete or to t pipe being used too green. Both of these defects can easily be guard against by a rigid system of inspection. The quality of the concre itself in concrete culvert pipe, as well as in concrete piles or in any oth structure composed of this material is of the first importance. If a ric dense concrete which is allowed to cure a reasonable length of time provided in reinforced concrete pipe which are intelligently designed a

0=2.62 in.

in.

e require
on 4½ in.

to space
rods can
hould be
ll at the
sides of
occurs.
the use
rawings
methods
ssary to

ete pipe
be the
ided on
of what
atisfac-
ed dry-
ery lit-
kes its
other
it did

pipe
ndard,
some

ows a
while
they

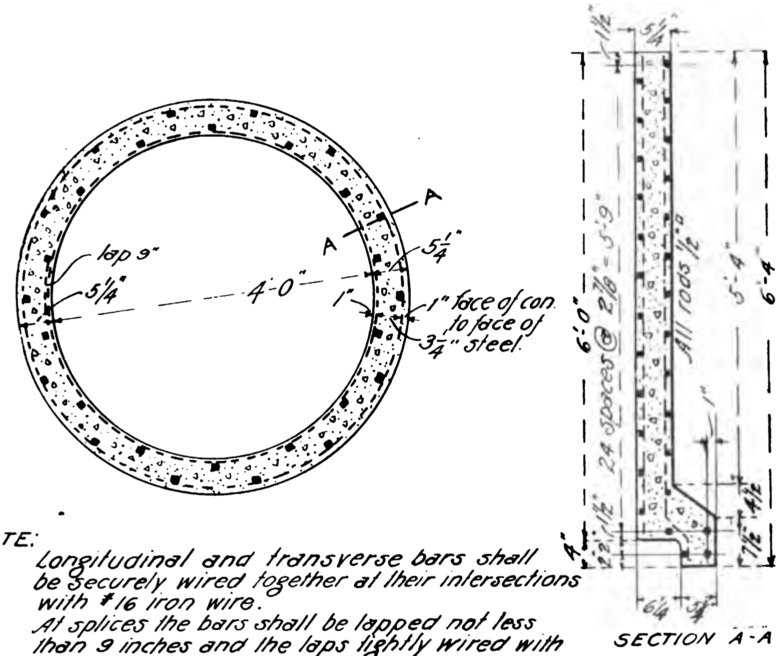
ques-
lling.
rable
the
the
rded
crete
ther
rich,
e is
and

installed we believe that the railroads should feel perfectly safe in adopting this construction wherever it seems desirable to do so.

The questions in the tabulation of the replies concerning the cost of concrete culvert pipe were formulated with the desire to show the costs of the separate steps which taken together represent the total cost in place as well as to give a general idea of the cost of cast iron pipe in place of the same diameter. The replies are given with as much explanation as possible under the head of "remarks" in the hope that some of those interested in this feature of the subject may find some information of value.

The committee feels that the tabulations contained in this report, except for the few roads that had not reported at the time they were made up, fairly represent the practice of the railways of this country in respect to reinforced concrete culvert pipe. The several photographs which appear in connection with this report are reproduced for the purpose of showing several rather interesting features of the use and manufacture of concrete pipe.

H. Rettinghouse,
S. T. Corey,
G. H. Stewart,
C. F. Urbutt,
Committee.



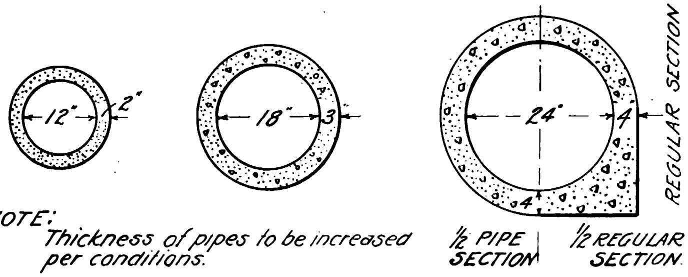
NOTE:
Longitudinal and transverse bars shall be securely wired together at their intersections with #16 iron wire.
At splices the bars shall be lapped not less than 9 inches and the laps tightly wired with 24 turns of #16 iron wire.

Michigan Central R.R., Reinforced Concrete Culvert Pipe.

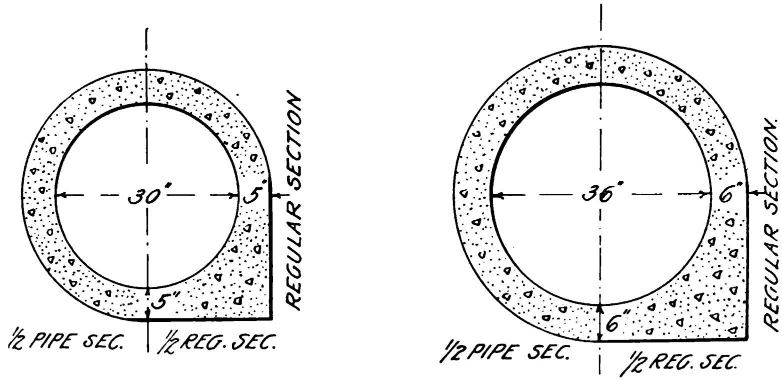
1¼ Bbls cement assumed per cu. yd of concrete.

		PIPE SECTION		REGULAR SECTION		
Inside Diam. Inches	Min. thickness Inches	Cu. yds. per lineal foot	Bbls cement per lineal foot.	Cu. Yds. per lineal foot.	Bbls Cement per lineal foot.	End Walls Blue Print Nos.
12	2	0.02262	0.02828			
18	3	0.05091	0.06364			12895
24	4	0.09050	0.11312	0.11876	0.14845	12894
30	5	0.14140	0.17675	0.18556	0.23195	4647
36	6	0.20362	0.25452	0.26721	0.33401	12893.

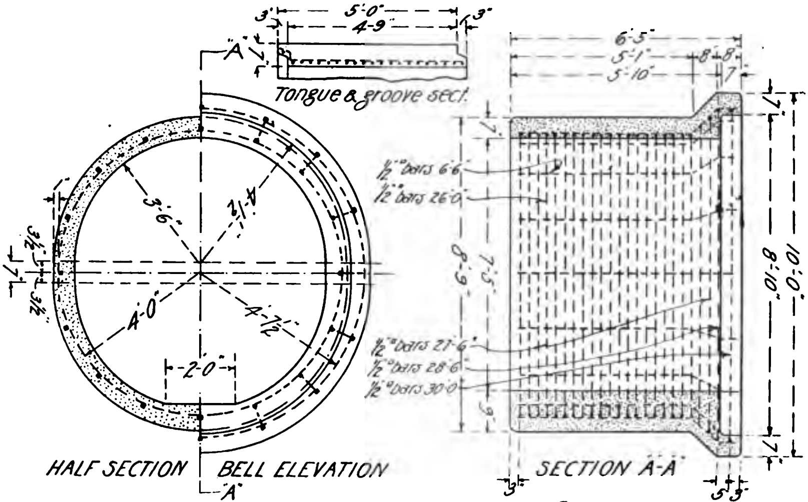
NOTE:
When pipe is laid continuously, excavate to conform with the base, make excavation slightly full; the lower section, about ⅓ of the pipe, is then to be tamped into place, the inside of pipe being formed with templates and straight-edge, regular forms similar to those used for arches are then to be built and the balance of the pipe completed. Use only best cement for concrete pipe.
Rock to be 2" or thereabouts and smaller. Do not use concrete pipe on steep transverse slopes. Do not load or take out forms too soon. In very bad foundation, additional thickness of concrete to be placed under pipe to suit foundation conditions.



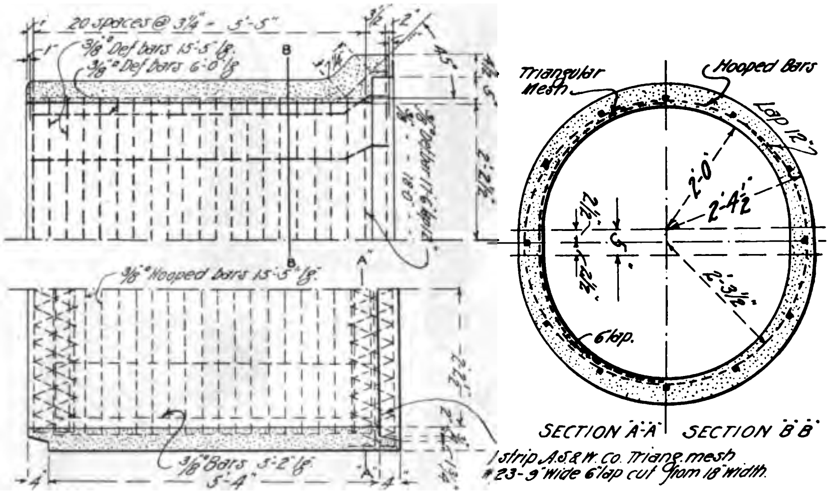
NOTE:
Thickness of pipes to be increased per conditions.



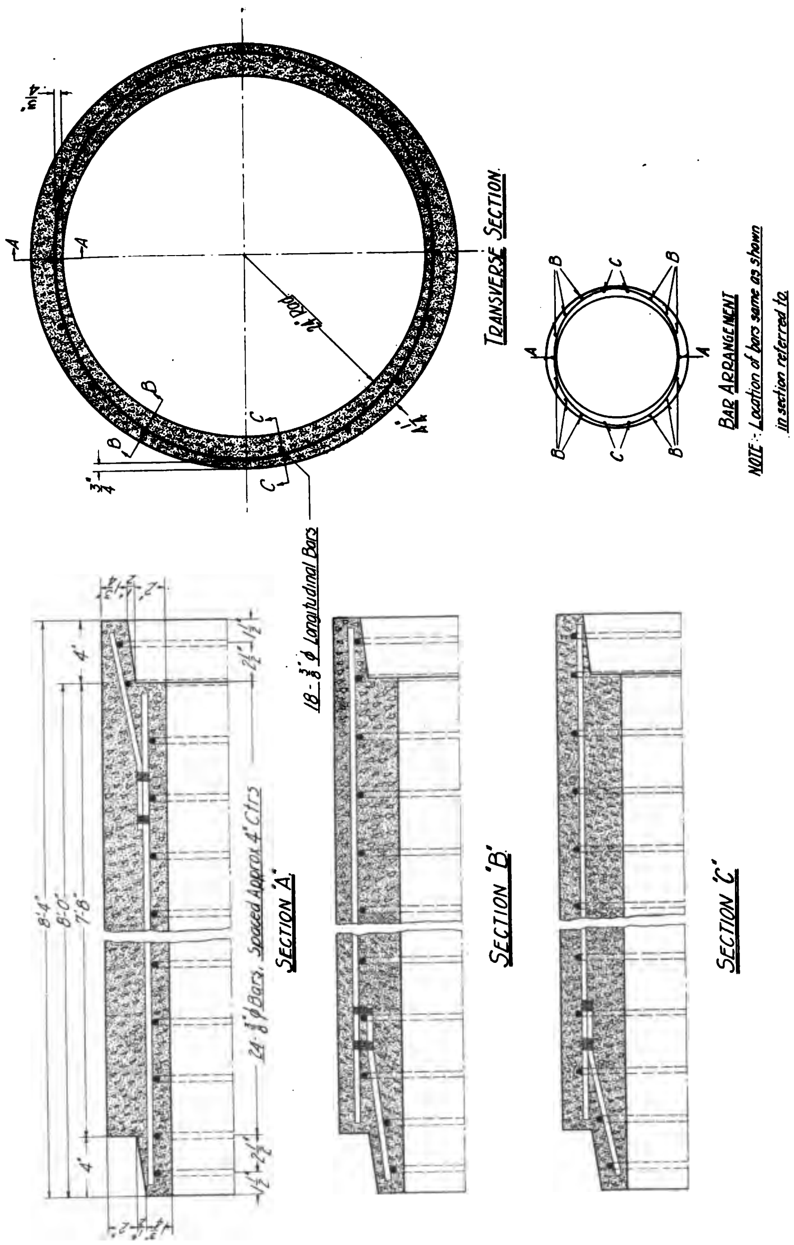
Concrete Pipe Culverts, Southern Pacific Co.



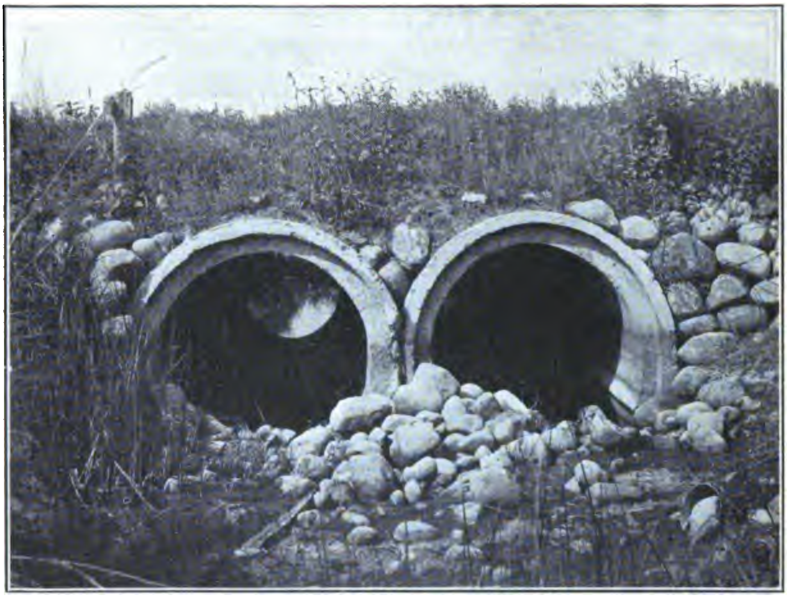
Minneapolis, St. Paul & Sault Ste. Marie Ry. — Reinforced Concrete Culvert Pipe.
Standard Cattle Pass.



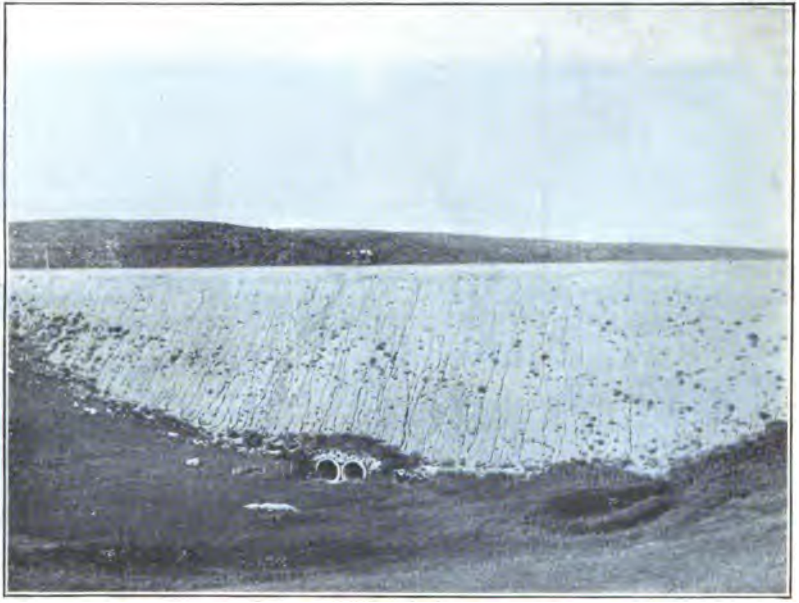
Great Northern Ry., Reinforced Concrete Culvert Pipe.


TRANSVERSE SECTION
24" Rad.
4½"
¾"
A
B
C
18-⅜" φ Longitudinal Bars
BAR ARRANGEMENT
NOTE: Location of bars same as shown in section referred to
SECTION 'A'
24-⅜" φ Bars, Spaced Approx 4" Ctrs
8'-4"
8'-0"
7'-8"
4"
2½"
1½"
SECTION 'B'
SECTION 'C'

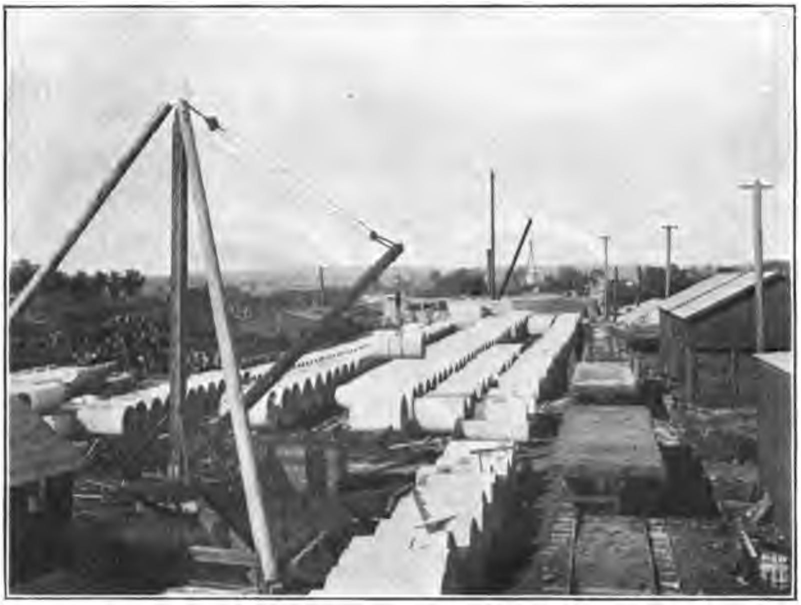
Standard 48 In. Culvert Pipe, Built by C. F. Massey Co. for C. & N. W. Ry.



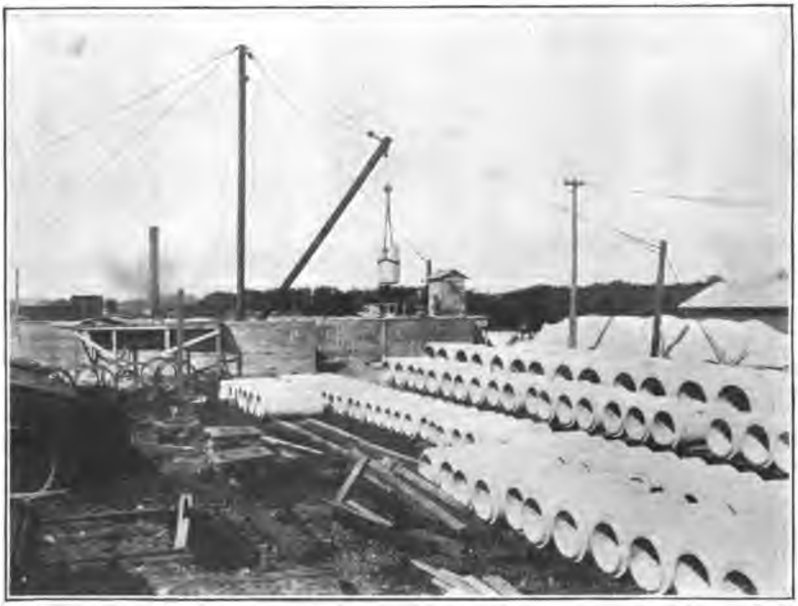
Two Lines of 60-In. Reinforced Concrete Culvert Pipe with Two Feet of Covering.



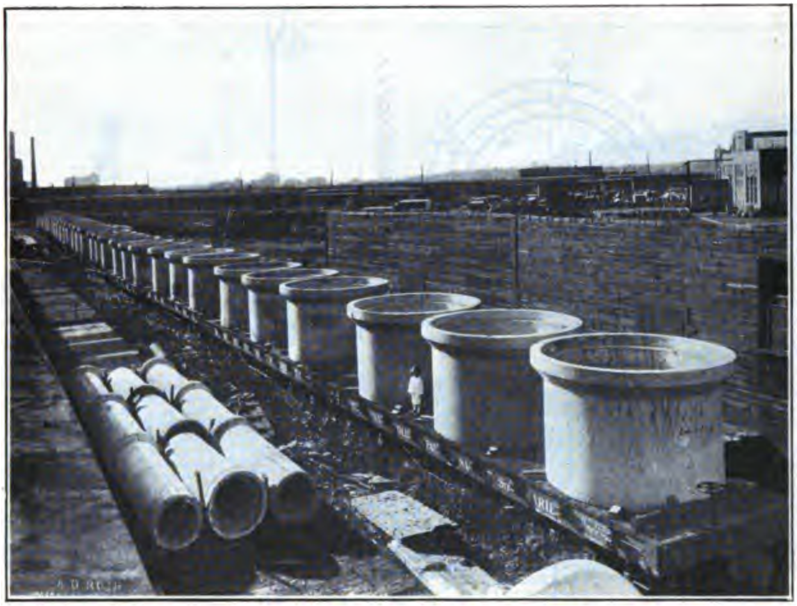
Two Lines of 60-In. Reinforced Culvert Pipe Under a 70-Ft. Embankment.



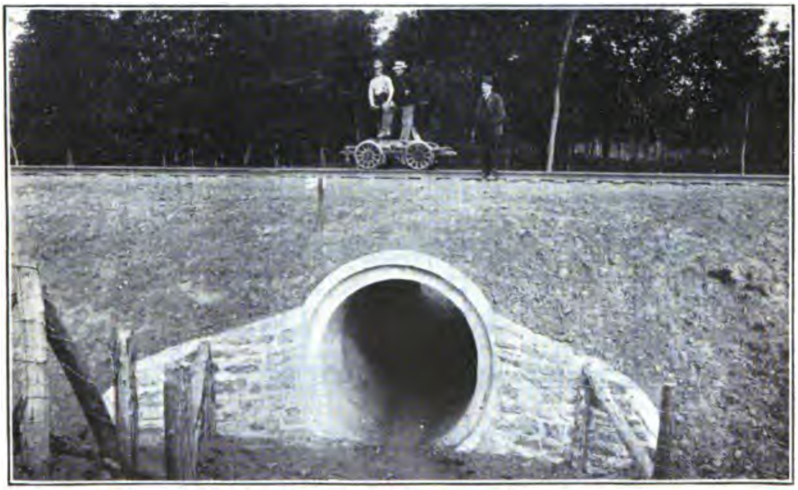
Concrete Culvert Pipe Plant of the Chicago, Milwaukee & St. Paul Ry., at Tomah, Wis.



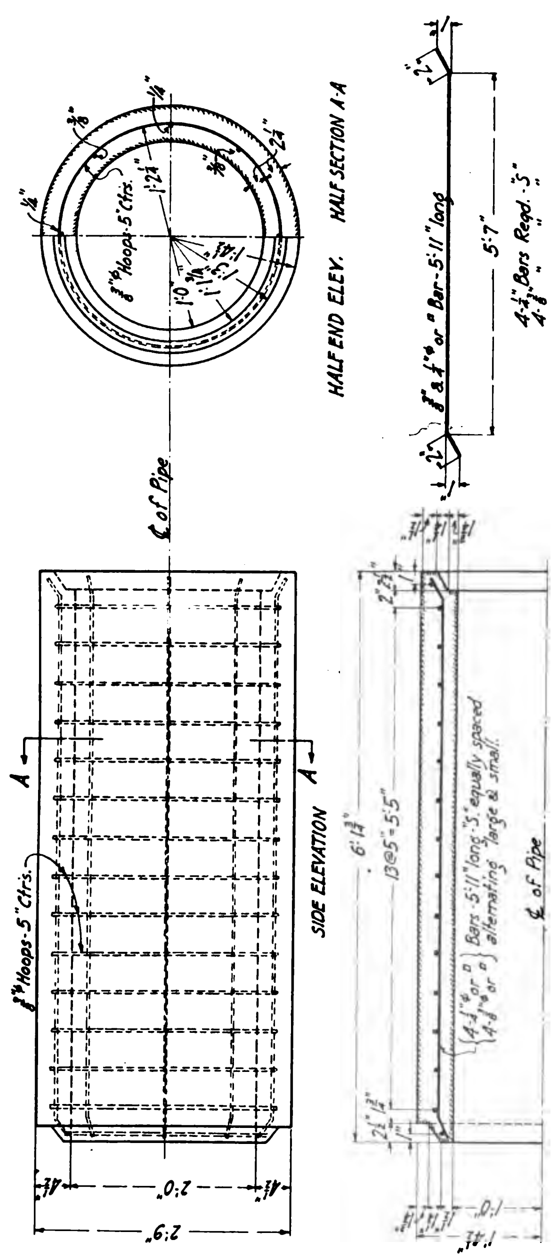
Concrete Culvert Pipe Plant of the Chicago, Milwaukee & St. Paul Ry., at Tomah, Wis.



A Train Load of 84 In. by 89 In. Reinforced Concrete Culvert Pipe, Designed for Use as Cattle Passes.

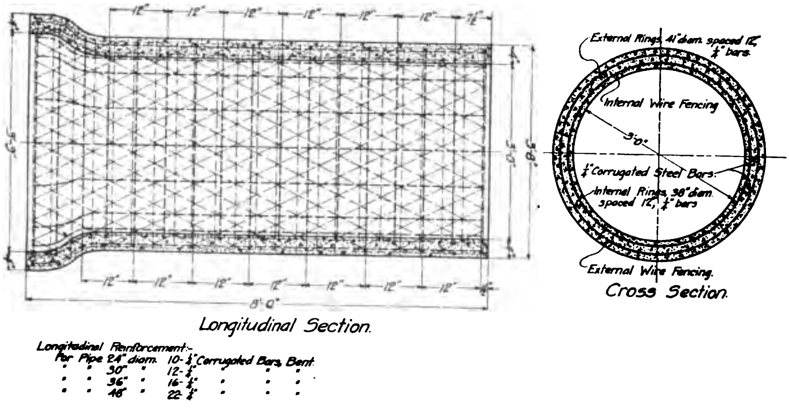


One of the 89-In. Cattle Pass Culverts in Place.



Heavy Concrete Culvert Pipe, 24-inch, C. M. & St. P. Ry.

Concrete Pipe and Post Plant, B. R. & P. Ry., East Salamanca, N. Y.


12"
7½"
8'-0"
Longitudinal Section.
External Rings 41" diam. spaced 12", ¼" bars.
Internal Wire Fencing
3'-0"
¼" Corrugated Steel Bars.
Internal Rings 38" diam. spaced 12", ¼" bars
External Wire Fencing.
Cross Section.
Longitudinal Reinforcement:-
For Pipe 24" diam. 10-¼" Corrugated Bars, Bent.
" " 30" " 12-¼" " " "
" " 36" " 16-¼" " " "
" " 48" " 22-¼" " " "

Reinforced Concrete Culvert Pipe, Wabash R. R.

APPENDIX B.

American Society of Civil Engineers' list of articles on the manufacture and use of concrete pipe, from a search made by the librarian of the Society, Dec. 16, 1914.

(Note:—This is not a complete bibliography, but it includes readily accessible material for the years, 1908-1914.)

1908.

"Reinforced Concrete Pipe for Carrying Water under Pressure," by Chester Wason Smith, Assoc. M. Am. Soc. C. E. Trans. Am. Soc. C. F., v. 60, p. 124 (Paper 1065, June). (This paper describes the construction of about 6,000 ft. of reinforced concrete pipe intended to carry water under pressure, and also gives the results attained and some figures as to the cost; 36 pages, illustrated.)

"Tests of Cast-Iron and Reinforced Concrete Culvert Pipe," by Arthur N. Talbot. University of Illinois Engineering Experiment Station, Bulletin No. 22 (April). (Results of tests of culvert pipe; 65 pages, illustrated.)

"Ferro-Concrete Pipe-Weaving Machine." Engineering, v. 86, p. 151 (July 31). (Describes the machine used for making Siegwart pipe; ½ page.)

"A Traveling Mold for Making Reinforced-Concrete Pipe," by F. Teichman, M. Am. Soc. C. E. Eng. News, v. 59, p. 184 (Feb. 20). (Describes the making of the concrete pipes for the Salt River project of the United States Reclamation Service; 2 pages, illustrated.)

"Reinforced-Concrete Intercepting and Outfall Sewer, Waterbury, Conn.," by Wm. Gavin Taylor, M. Am. Soc. C. E. Eng. News, v. 59, p. 333 (March 26). (Design, method of construction and cost; 3 pages, illustrated.)

"The Big Cottonwood Waterworks Conduit of Salt Lake City, Utah." Mun. Eng., v. 35, p. 148 (Sept.). (4 pages, illustrated.)

"The Construction of a Reinforced Concrete Intercepting Sewer," by Alexander J. Taylor. Proceedings, American Society of Municipal Improvements, p. 110. (On sewer pipe constructed by the City of Wilmington, Delaware; 10 pages, illustrated.)

Abstracts of same. "Building a Reinforced Concrete Pipe Sewer," by Alexander J. Taylor. Mun. Eng., v. 36, p. 5 (Jan., 1909). (2½ pages.) Surveyor, Municipal and County Engineer, v. 35, p. 397 (March 19, 1909); "Reinforced Concrete Intercepting Sewer," by Alexander F. Taylor. Municipal Journal and Engineer, v. 25, p. 707 (Nov. 18). (4 pages, illustrated.) Eng. Rec., v. 58, p. 517 (Nov. 7).

"The Harlem Creek Sewer and Its Steel Centering: St. Louis, Mo." Eng. News, v. 60, p. 131 (July 30). (States that this is thought to be the largest concrete sewer built in this country; 2 pages, illustrated.)

"Reinforced-Concrete Pipe with Reinforced Joint." Eng. News, v. 60, p. 643 (Dec. 10). (Describes pipe manufactured by the Lock Joint Pipe Co., of New York; 2 col., illustrated.)

"Conduit of Special Design in Ogden, Utah." Eng. Rec., v. 57, p. 65 (Jan. 18). (1 page, illustrated.)

"A Notable Ground-Water Development at Pueblo, Colo." Eng. Rec., v. 57, p. 399 (April 4). (More than 18,000 linear feet of hub and spigot concrete pipe, in 30 and 38-in. sizes was made in connection with the project, details of the construction of the pipe are given; 3 pages, illustrated.)

"A Large Double-Barrel Sewer Built Across a Salt Marsh." Eng. Rec., v. 57, p. 409 (April 4). (Describes the construction of a reinforced concrete sewer; 2 pages, illustrated.)

"Tests of Cast Iron and Reinforced Concrete Culvert Pipe," by Arthur N. Talbot. Journal, Western Society of Engineers, v. 13, p. 376 (June). (Results of tests made at the University of Illinois, Engineering Experiment Station; 57 pages, illustrated.)

"Some Methods Employed in Constructing the 7⅓ Mile Reinforced Concrete Aqueduct for the Water Supply of Salt Lake City." Engineering-Contracting, v. 30, p. 78 (Aug. 5). (Details of construction of Big Cottonwood Conduit; 2 pages, illustrated.)

"Method and Cost of Moving Steel Forms for an 8 Ft. Concrete Sewer." Eng. Con., v. 30, p. 146 (Sept. 2). (1 page, illustrated.)

"Reinforced Concrete Block Construction for Culverts and Sewers." Eng. Con., v. 30, p. 147 (Sept. 2). (1½ pages, illustrated.)

"The Reinforced Concrete Sewer in Avenue A, Borough of the Bronx." Eng. Rec., v. 58, p. 368 (Oct. 3). (2 pages, illustrated.)

"A Large Concrete Sewer Constructed with Adjustable Metal Forms," by John M. Bruce, Assoc. Am. Soc. C. E. Eng. News, v. 60, p. 386 (Oct. 8). (2 pages, illustrated.)

"The Water-Supply System of Salt Lake City, Utah." Eng. Rec., v. 57, p. 351 (March 21). (Contains description of Cottonwood conduit of reinforced concrete; 1 page, illustrated.)

"Reinforced Concrete Sewers in Wilmington, Delaware." Eng. Rec., v. 57, p. 621 (May 9). (1 page, illustrated.)

"Time of Removal of Centers in Concrete Sewer Construction," by Albert C. Lehman. Eng. Rec., v. 58, p. 664 (Dec. 12). (Investigation made by the Blaw Collapsible Steel Centering Company; 1 col.)

"The Contractor's Plant for Building a Triple Barrel Reinforced Concrete Sewer." Eng. Rec., v. 58, p. 630 (Nov. 28). (On construction of sewer, Borough of the Bronx, New York City; 2 pages, illustrated.)

"Die Anwendung des Stampfbetons bei den Dresdener Kanalbauten," by Pressprich. Beton und Eisen, v. 7, p. 139, 161 (April 22, May 14). (The employment of rammed concrete in the Dresden sewer; 8 pages, illustrated.)

"A Reinforced Concrete Block Sewer," by Burton Lowther. Cement Age, v. 7, p. 318 (Oct.). (3 pages, illustrated.)

"Eine bewegliche Form zur Herstellung von Eisenbetonröhren," by Fr. Lorey. Beton und Eisen, v. 7, p. 287 (Sept. 24). (Describes a movable form for the construction of reinforced concrete pipe; 3 pages, illustrated.)

"Der Bau des Abwasser-Samelkanales in Osnabrück und die an demselben beobachteten Zerstörungs-Erscheinungen durch Einwirkung schwefelsauren Moorbezw. Grundwassers," by Friedrich Lehmann. Deutsche Bauzeitung, v. 42, p. 466 (Aug. 22). (On reinforced concrete sewer in Osnabrück; 2 pages, illustrated.)

"Sewer Construction in Chicago." Municipal Journal and Engineer, v. 25, p. 771 (Dec. 2). (Description of the first concrete sewer work done in Chicago; 5 pages, illustrated.)

"Reinforced-Concrete Conduits for Electric Cables, Long Island R. R.," by Frederick Auryansen, Assoc. M. Am. Soc. C. E. Eng. News, v. 60, p. 90 (July 23). (½ page.)

"Concrete and Reinforced Concrete Sewers." In "Sewer Construction," p. 52, by Henry N. Ogden. N. Y. John Wiley & Sons. (36½ pages.)

"Methods and Cost of Aqueduct and Sewer Construction." In "Concrete Construction Methods and Cost," p. 532, by Halbert P. Gillette, M. Am. Soc. C. E. and Charles S. Hill. N. Y. Myron C. Clark Publishing Co. (56 pages, illustrated.)

"Tests of the Impermeability of Reinforced Concrete Pipe," by W. A. Burton. Engineering Experiment Station, Iowa State College, Bulletin No. 21, p. 20. (25 pages, illustrated.)

1909.

" A Jointless Concrete Sewer Pipe." Cement and Engineering News, v. 21, p. 391 (Nov.). (1 par.)

" Concrete Sewers Preferred." Cement and Engineering News, v. 21, p. 382 (Nov.). (½ col.)

" Some Structural Details and Notes on Construction of a Reinforced Concrete Pipe Sewer." Eng. Con., v. 32, p. 369 (Nov. 3). (On sewer pipe in Waukegan, Ill.; 1 page, illustrated.)

" A Concrete and Steel Storm Water Sewer and Some Remarks on Specifications and Designs." Eng. Con., v. 32, p. 376 (Nov. 3). 2 pages, illustrated.)

" Specifications for Concrete Sewers at Richmond, Ind." Eng. Con., v. 32, p. 558 (Dec. 29). (1 page, illustrated.)

" A Large Reinforced Concrete Sewer." Eng. Rec., v. 59, p. 711 (June 5). (Details of construction of sewer in the northern part of St. Louis; 1¼ pages.)

" Methods and Cost of Constructing a Concrete Sewer in Freezing Weather." Eng. Con., v. 31. p. 65 (Jan. 27). (Itemized cost of monolithic concrete sewer, 1,360 ft. long and 30 ins. inside diam. constructed at Fond du Lac, Wis.; 1½ pages.)

" Machine a Mouler les Tuyaux en Ciment." Portfeuille Economique des Machines, 5th series, v. 7, p. 182 (Dec.). (Machine for molding cement pipe; 1½ pages.)

" Ein bewegliche Form zur Herstellung von Eisenbetonröhren," by Ziegler. Beton und Eisen, v. 8, p. 99, 116 (March 10, April 2). (A movable form for the construction of reinforced concrete pipes; 2 pages.)

" Reinforced Concrete Pipe. In Sanitary Engineering," v. 1, p. 77, by E. S. C. Moore and E. J. Silcock. Third Edition. Lond. B. T. Batsford, 94 High Holborn. (4½ pages, illustrated.)

" A Twelve-Mile Concrete Pipe Conduit." Eng. Rec., v. 60, p. 514 (Nov. 6). (This pipe was built as a part of the plant of the Eastern Colorado Power Company in northeastern Colorado; 2 pages, illustrated.)

Editorial on Same. " Concrete Pipe for Flow Lines." Eng. Rec., v. 60, p. 506 (Nov. 6). (2 col.)

" Sewer Construction in San Francisco," by O. D. Johns. Eng. Rec., v. 60, p. 608 (Nov. 27). (Construction of a concrete sewer with a brick invert; 2 pages, illustrated.)

" Laying a Subaqueous Reinforced-Concrete Pipe with Cast-Iron Flange Connection." Eng. News, v. 62, p. 95 (July 22). (Details of Lock-Joint Pipe laid as suction pipes by the Public Service Corporation of New Jersey at Marion, N. J.; ½ page, illustrated.)

" The Design of an Eight-Mile High-Head Hydraulic Conduit," by Lars Jorgensen, Assoc. M. Am. Soc. C. E. Eng. News, v. 62, p. 146 (Aug. 5). (Gives design of concrete flow pipe and comparison of cost of concrete pipe, timber flume and wood stave pipe; 1½ pages, illustrated.)

" Reinforced-Concrete Pipe Specials used in the Water Supply of Paris, France." Eng. News, v. 62, p. 252 (Sept. 2). (½ col., illustrated.)

" The Cost of a Five-foot Concrete Inverted Syphon." Eng. Rec., v. 59, p. 124 (Jan. 30). (Itemized cost of Belle Fourche River Concrete inverted syphon; ½ page.)

" A Notable Mexican Concrete Conduit (Letter)," by James D. Schuyler. Eng. Rec., v. 59, p. 727 (June 5). (Illustrated description of sewer design and materials used; 1 page.)

" Construction of a Concrete Block Sewer in Toledo, Ohio," by Frank I. Consaul. Eng. Rec., v. 61, p. 123 (Feb. 4). (The plans for the sewer were prepared in accordance with the design and patents of Walter C. Parmley; 1 page, illustrated.)

" Concrete Sewers at Richmond, Indiana," by Fred R. Charles and

Dell B. Davis. Proceedings, Indiana Engineering Society, v. 29, p. 112. (Describes method of construction of sewer; 4 pages.)

Abstract of same. " Concrete Monolithic and Pipe Sewers at Richmond, Ind.," by Fred R. Charles and Dell B. Davis. Eng. News, v. 61, p. 186 (Feb. 18).

1910.

" Constructing Concrete Sewers in Open Trench." Eng. Rec., v. 61, p. 516 (April 16). (The sewer was built in Stapleton, Staten Island; 1 page, illustrated.)

" Reinforced-Concrete Syphon for a 65 ft. Head." Eng. Rec., v. 62, p. 39 (July 9). (Details of the construction; 1 page, illustrated.)

" A Reinforced-Concrete Conduit Operating under a Head." Eng. Rec., v. 62, p. 109 (July 23). (Details of design and construction of conduit at Salt Lake City; 1½ pages, illustrated.)

" Reinforced Concrete Sewers in Soft Ground, Seattle." Eng. Rec., v. 62, p. 466 (Oct. 22). (1 page, illustrated.)

" Cut and Cover Construction on the Catskill Aqueduct." Engineering Record, v. 61, p. 36 (Jan. 8). (The aqueduct will be of concrete 17 ft. high and 17½ ft. wide inside dimensions; 3½ pages illustrated.)

" A Large Storm Sewer Supported on Piers." Eng. Rec., v. 61, p. 338 (March 19). (Describes an 11x13 ft. rectangular reinforced concrete sewer carried on concrete piers, constructed in Philadelphia; 1 page, illustrated.)

" Hydroelectric Development on the Weber River, Utah." Eng. Rec., v. 61, p. 456 (April 2). (Contains a description of a 7-ft. continuous reinforced-concrete pipe built in place; 2 col., illustrated.)

" Methods and Cost of Constructing a Concrete Sewer in Freezing Weather." Cement and Engineering News, v. 22, p. 60, (Feb.). (On construction of sewer at Fond du Lac, Wisconsin; 2 pages.)

" Methods of Constructing the Western Ave. Sewer, Chicago, Ill." Eng. Con., v. 33, p. 405 (May 4). (Details of making concrete sewer; 2 pages, illustrated.)

" Cement Pipe for Sewer Purposes," by O. U. Miracle. Cement Age, v. 10, p. 192 (March). (3 pages.)

" Concrete Sewers, Richmond, 1909," by Fred R. Charles and D. B. Davis. Proc. Indiana Eng. Soc., p. 163. Charles Brosman, Sec'y, Indianapolis, Ind. (Gives cost of concrete sewer pipe; 6 pages.)

Abstract of same. " Concrete Sewers at Richmond, Ind.," by Frederic R. Charles. Eng. News, v. 63, p. 118 (Feb. 3). (1¼ pages.)

" The Jones Falls Covered Conduits and Boulevard, Baltimore." Eng. Rec., v. 62, p. 637 (Dec. 3). (Typical sections of the Jones Falls conduits; 1 page.)

" Difficult Construction of Concrete Sewer," by Maury Nicholson. Municipal Journal and Engineer, v. 28, p. 203 (Feb. 9). (Details of sewer at Birmingham, Alabama; 3 pages, illustrated.)

" The Richmond Concrete Conduit," by J. A. Johnston. Municipal Journal and Engineer, v. 28, p. 572 (April 20). (On the design of a reinforced concrete conduit, 2 pages, illustrated.)

" Concrete Pipe at Toronto, Pipe 36 to 72 in. in Diameter," by Francis F. Longley. Mun. Jour. and Engr., v. 28, p. 762 (May 25). (1 page, illustrated.)

" Röhre aus Zementbeton." In " Handbuch der Ingenieurwissenschaften, Dritter Teil," " Der Wasserbau," Vierter Band " Die Entwässerung der Städte," p. 130, 169. Leipzig. Wilhelm Engelmann. (On concrete pipe and their testing; 7 pages.)

" Röhrenförmige Leitungen und offene Kanäle Aquedukte und Kanalbrücken aus Eisenbeton," by D. Lorey. In " Handbuch für Eisenbetonbau, 5 Band, " Flussigskeits-Behälter, Röhren, Kanäle," p. 595 2 Auflage. Berlin. Wilhelm Ernst & Sohn. 20 Marks. (On reinforced concrete pipes; 72 pages, illustrated.)

Concrete Sewers. In "Sewerage, the Designing, Construction and Maintenance of Sewerage Systems," p. 147, 192, 198, 225, 300, by A. Prescott Folwell, M. Am. Soc. C. E. Sixth Edition. N. Y. John Wiley & Sons, 432 Fourth Avenue. (Brief data on concrete sewers.)

1911.

"The Waterworks and Sewerage of Monterey, N. L., Mexico," by George Robert Graham Conway, M. Am. Soc. C. E. Transactions, American Society of Civil Engineers, v. 72, p. 497, 573 (Paper 1193, June). (Contains details of manufacture, cost, etc., of concrete pipe.)

Abstract of same. "Method and Cost of Molding and Laying Reinforced Concrete Pipe for an Aqueduct, Monterey, Mexico, Waterworks." Engineering-Contracting, v. 35, p. 53 (Jan. 11). (2 pages, illustrated.)

"The Tieton Canal," by E. G. Hopson, M. Am. Soc. C. E. Trans. Am. Soc. C. E., v. 71, p. 158 (Paper 1181, March). (On the design and manufacture of reinforced concrete conduits.)

"Installation and Capacity of Reinforced Concrete Syphons," by Zenas A. Vaughn. Journal Idaho Society of Engineers, v. 1, p. 36 (May). (8 pages.)

Abstract of same. "Building a Reinforced-Concrete Pipe-Line in Alkali Soil," by Zenas N. Vaughn. Eng. News, v. 65, p. 787 (June 29). (1 page.)

"The Thirty-Eighth Street Sewer, Minneapolis." Eng. Rec., v. 63, p. 382 (April 8). (1¼ pages, illustrated.)

"Constructing a Concrete Storm Sewer at Montgomery," by G. C. Bayles. Eng. Rec., v. 63, p. 700 (June 24). (1 page, illustrated.)

"Two Large Subaqueous Concrete Pipe Lines at Perth Amboy." Eng. Rec., v. 64, p. 195 (Aug. 12). (Concrete pipes were laid to serve as intakes for supplying salt water to the condensers of the power plant of the Public Service Corporation of New Jersey; 1 page, illustrated.)

"Construction of the Richmond Hill Trunk Sewer, Borough of Queens." Eng. Rec., v. 64, p. 362 (Sept. 23). (3 pages, illustrated.)

"Heavy Sewer Work in St. Louis, a 15-Foot Reinforced Concrete Section Requiring a Cut of 40 Ft." Eng. Rec., v. 64, p. 410 (Oct. 7). (1 page, illustrated.)

"Gaugings in the Concrete Conduit of the Umatilla Project, Measuring Losses due to Friction and Curvature to Find Channel Efficiencies," by F. G. Hopson. Eng. Rec., v. 64, p. 480 (Oct. 21). (1¼ pages, illustrated.)

"Reinforced-Concrete Pressure Pipe on the Umatilla Project, Ore., U. S. Reclamation Service," by Herbert D. Newell, Assoc. M. Am. Soc. C. E. Eng. News, v. 65, p. 208 (Feb. 16). (Details of forms used for pipe, pipe making, durability and cost; 2½ pages, illustrated.)

"Cement Pipe and Tiles," by E. S. Hanson. 2nd Edition Chicago, Cement Era Publishing Co. (States advantages of cement for pipe and tile, methods of manufacture tests, cost, etc.)

"The Manufacture of Reinforced Concrete Poles, Piles and Pipes without the use of Forms; Process of R. M. Jones. Denver, Colo., 1914. (Pamphlet, 27 pages, illustrated.)

"Specifications for and Cost of Concrete Sewer Pipe at Bellingham, Wash.," by H. A. Whitney. Cement and Eng. News, v. 23, p. 279 (Aug.). (1 page.)

"Reinforced Concrete Pipes," by Arch. Currie. Can. Engr., v. 21, p. 454 (Oct. 19). (2 pages.)

"Reinforced Concrete Sewer in Grand Rapids." Municipal Journal and Engineer, v. 31, p. 619 (Nov. 15). (3 pages, illustrated.)

"Intercepting Sewer and Sewage Pumping Station," by Robert Hooke. Municipal Journal and Engineer, v. 30, p. 605 (May 3). (Reinforced concrete pipe was used in tunnel under railroad track.)

"Jones Falls Conduits, Baltimore." Mun. Jour. and Engr., v. 31, p.

683 (Nov. 29). (Description of reinforced concrete conduits, showing standard sections; 4 pages, illustrated.)

"Sewer Construction at Regina, Saskatchewan, Canada," by W. R. Harris. Canadian Engineer, v. 20, p. 547 (April 13). (The sewer is constructed with concrete pipe manufactured by the Lock Joint Pipe Company under the Meriwether patents; 3 pages, illustrated.)

"Comparative Advantages of Clay, Fibre and Concrete Conduits for Signal Wires." Eng. Con., v. 36, p. 90 (July 26). (2 pages, illustrated.)

1912.

"Reinforced Concrete Culvert Pipe." Proceedings of the American Bridge and Building Association, v. 22, p. 87. (Report of the Committee on reinforced concrete culvert pipe, data on fitness for use in embankments, types of pipes, extracts from letters received in response to letter of inquiry and details of construction of concrete pipe by the Chicago, Milwaukee & St. Paul Ry. at Tomah, Wis.; 28 pages.)

Brief abstract of same. "Concrete Pipe Culverts in Railway Work." Concrete-Cement Age, v. 1, Nov., p. 72. (1 col.)

"Enclosing a Sewage-Laden Stream in a Triple-Barrel Concrete Conduit, Concrete for the Jones Falls Improvement at Baltimore was Distributed from Hoppers at the Tops of Tall Wooden Towers." Eng. Rec., v. 65, p. 284 (March 16). (Details of the design and construction of the conduits; 2½ pages, illustrated.)

"Construction of a Large Sewer in Spokane," by R. A. Brackenbury. Eng. Rec., v. 66, p. 156 (Aug. 10). (The sewer is constructed throughout of reinforced concrete built in place; details of the design and construction; 2¼ pages, illustrated.)

"The Use of Concrete in Sewers." Municipal Engineering, v. 43, p. 365 (Dec.). (Elements of design of concrete sewers in several large cities; 7 pages, illustrated.)

"Concrete in Sewer Construction," by W. J. Baird. Applied Science, v. 6, p. 41, (June). (Discusses how concrete sewers compare with those of other materials in cost, durability and resistance to chemical action; 19 pages.)

"Large Sewers in Newark, N. J.," by E. S. Rankin. Mun. Jour. and Engr., v. 33, p. 595 (Oct. 24). (The main lines are to be built throughout of monolithic concrete; 3 pages, illustrated.)

"Reinforced Concrete Inverted Syphons on a Main Canal." Eng. Rec., v. 66, p. 93 (July 27). (1 page, illustrated.)

"Design and Construction of the O. K. Creek Sewer, Kansas City, Mo." Eng. Rec., v. 66, p. 480 (Nov. 2). (3½ pages, illustrated.)

"Construction on the Los Angeles Aqueduct." Eng. Rec., v. 65, p. 6 (Jan. 6). (Contains details of reinforced concrete conduit.)

"The Action of Alkali on Cement Pipe Lines," by Will L. Brown. Cement and Engineering News, v. 24, p. 227 (Aug.). (1 page.)

"Concrete Pipe 40 Years Old." Mun. Jour. and Engr., v. 32, p. 870 (June 6). (½ page, illustrated.)

"Prescribed Procedure for Laying 9-Ft. Steel or Concrete Pipe in Existing 12-Ft. Brick Water Supply Conduit at Baltimore, Old Conduit Alternately In and Out of Service." Eng. Con., v. 41, p. 162 (Feb. 4). (The concrete pipe will be manufactured and placed by the Lock Joint Pipe Company of New York City; 1 page illustrated.)

"Combined Sewer and Bridge in Denver." Eng. Rec., v. 66, p. 272 (Sept. 7). (Design and construction of a combined sewer and bridge of reinforced concrete spanning the canal of the Denver Union Water Company; 1 page, illustrated.)

"A Large Concrete Pressure Pipe," by F. W. Hanna, Eng. News, v. 68, p. 248 (Aug. 8). (Description of the Forest Pipe Line of the Boise project, 1¾ miles of 36-in. pipe under approximately 70-ft. head; 4 pages, illustrated.)

"New Sewer Work at St. Louis, Mo.," by W. W. Horner. Eng. News, v. 68, p. 431 (Sept. 5). (Includes a description of a short section of concrete box-girder sewer; 1 page.)

"Reinforced Concrete Pipe Construction for Regina Sewer," by W. R. Harris. Cement and Engineering News, v. 24, p. 82 (March). (2½ pages.)

"The Reinforced Concrete Pipe Co." Cement and Engineering News, v. 24, p. 76 (March). (Illustration showing methods of reinforcing concrete pipe, devices employed in laying the pipe, etc., 1 par.)

"Uber die Zerstörung von Zementrohren," by Eger. Zentralblatt der Bauverwaltung, v. 32, p. 279 (May 29). (½ page, illustrated.)

"Eisenbetonkanal des Hauptwassersammlers zu Lichtenberg," by E. Schlotterer und Max Rüdiger. Beton und Eisen, v. 11, p. 305 (Aug. 24). (Reinforced concrete sewer in Lichtenberg; 2 pages, illustrated.)

"Specifications for the Manufacture, Testing Dimensions, and Laying of Plain Concrete Sewer Pipe, Kansas City, Mo." Eng. Con., v. 37, p. 447 (April 17). (1 page.)

"An Economic Study of Water Pipe Line Materials Available for the Proposed Conduit at Port Arthur, Texas." Eng. Con., v. 38, p. 127 (July 31). (Includes comparative cost, capacity, etc., of concrete pipes; 3 pages.)

1913.

"Concrete Sewer Construction in Louisville," by J. H. Kimball. Municipal Journal and Engr., v. 44, p. 22 (Jan.). (3½ pages, illustrated.)

"Construction of a Concrete Sewer Tunnel through Difficult Ground," by H. S. Philips. Can. Engr., v. 24, p. 165 (Jan. 16). (3 pages, illustrated.)

"Eight-Mile Concrete Conduit at Baker, Oregon, Replacing a Wooden Flume with Molded Pipes without Interrupting Service." Eng. Rec., v. 67, p. 588 (May 24). (1 page, illustrated.)

"Forms for Monolithic Concrete Pipe and Manholes." Concrete-Cement Age, v. 2, p. 252 (May). (A Collapsible steel centering devised by L. Y. Stayton, Tacoma, Wash.)

"Atlas Concrete Pipe Machine." Concrete-Cement Age, v. 3, p. 44 (July). (3 pages, illustrated.)

"Some Data on Reinforcing Concrete Pipe," by Charles E. Sims. Concrete-Cement Age, v. 3, p. 204 (Nov.). (Theory and formula for reinforced concrete drain tile, results of tests; 1½ pages.)

"Röhrleitungen aus Beton bzw. Eisenbeton." In "Die Wasserkräfte," v. 2, p. 1164; by Adolf Ludin. Berlin. Julius Springer. (On pipe lines of concrete and reinforced concrete; 9½ pages, illustrated.)

"Concrete Pipe and Overflow Basins for Distributing Irrigation Water. Details of the System Used on the Sacramento Valley Project," by Eugene C. Mills. Eng. Rec., v. 67, p. 652. (June 14). (Details of the manufacture of the pipe and cost; 2¼ pages, illustrated.)

"Concrete Sewer-Pipe Tests in Kansas City," by E. S. Wallace. Eng. News, v. 69, p. 568 (March 20). (1 page, illustrated.)

"Studies of Co-efficient of Friction in Reinforced-Concrete Pipe, Umatilla Project, Oregon," by Herbert D. Newell. Eng. News, v. 69, p. 904 (May 1). (2 pages, with diagram of profile of pipe.)

"Pressure Tests of Jointed Concrete Pipes." Eng. News, v. 70, p. 1126 (Dec. 4). (Results of tests made by the Lock Joint Pipe Co. at Ampere, N. J., 1¼ pages.)

1914.

"Montreal Water Supply Conduit." Canadian Engineer, v. 26, p. 421 (March 5). (Report of the Board of Examiners outlining development of City's Water supply aqueduct, condition of the concrete conduit, general conclusions and recommendations; 5 pages, illustrated.)

"How Concrete has Helped Develop and Been Developed in the West," by Arthur H. Bent. Concrete-Cement Age, v. 4, p. 270 (June). (On concrete pipe; 2 pages.)

"Materials and Methods Used in the Manufacture of Concrete Sewer Pipe," by W. B. Dunning. Concrete-Cement Age, v. 4, p. 280. (June). (4 pages, illustrated.)

"Reinforced Concrete Sewer Design and Construction in St. Louis," by W. W. Horner, Concrete-Cement Age, v. 5, p. 139, 175 (Oct.). (5 pages, illustrated.)

"An Unusual Concrete Pipe Plant at Auburn, Wash." Railway Age Gazette, v. 56, p. 369 (Feb. 20). (The Northern Pacific Ry. casts 4 sections in each form daily by steaming the freshly poured forms; 2½ pages, illustrated.)

"Break and Repair of Montreal Conduit." Eng. Rec., v. 69, p. 277 (March 7). (The conduit was constructed of concrete lightly reinforced with Clinton wire cloth; 2½ pages, illustrated.)

"Kansas City Specifications for Sewer Pipe, and Experience in Testing Sewer Pipe," by Elwood S. Wallace. Eng. News, v. 71, p. 959 (April 30). (Comparison of clay and concrete pipe; 2 pages, illustrated.)

"Construction Methods and Costs for Large Concrete and Brick Sewers," by H. R. Abbott. Proceedings, Illinois Society of Engineers and Surveyors, v. 29, p. 59. (On construction and cost of plain concrete and reinforced concrete sewers in Chicago, 15 pages, illustrated.)

Abstract of same. "Methods and Cost of Constructing Large Brick and Concrete Sewers in Chicago, with Notes on Cost Keeping System Employed." Eng. Con., v. 41, p. 201 (Feb. 11).

"Spacing of Piers for Reinforced-Concrete Pipe, Method of Calculation, Taking into Consideration Stresses due to Water Pressure, Fill and Span," by Richard Muller. Eng. Rec., v. 70, p. 71 (July 18). (1 page, illustrated.)

"Interlocking Concrete Block Pipe," by A. F. Mattson. Concrete-Cement Age, v. 5, p. 85 (Aug.). (1 page, illustrated.)

"Building a Reinforced-Concrete Outfall Sewer Limited by Tides and Clearance." Eng. Rec., v. 69, p. 620 (May 30). (Details of work at Vancouver, B. C.; 1½ pages, illustrated.)

"Failure of 8-Ft. Reinforced Concrete Water Conduit at Montreal, Can.; City's Water Cut Off." Eng. News, v. 71, p. 54 (Jan. 1). (1 page.)

"Plain Concrete Sewer Pipe in Kansas City, Mo.," by F. S. Wallace. Proceedings, Illinois Society of Engineers and Surveyors, v. 29, p. 98. (8 pages.)

Abstract of same. "Concrete Sewer Pipe at Kansas City, Mo." Eng. News, v. 71, p. 347 (Feb. 12).

"Condition of the Montreal Water Conduit and Protective Measures." Eng. News, v. 71, p. 560 (March 12). (3 pages, illustrated.)

The Following References Can not Be Verified as Periodicals Are Not In the Library.

"Poles, Piles and Pipe Made without Molds," by R. M. Jones. Cement Era, Oct., 1913. (Illustrated description of a method of making reinforced concrete products; 2,200 words.)

"Reinforced Concrete Syphons across Sosa River and Canon of Ribabona," by B. A. Etcheverry. California Journal of Technology, Oct., 1909. (Illustrates and describes the method of construction; 3,000 words.)

"The Use of Concrete in Sewer Construction," by Peter Gillespie. Contract Record, Jan. 6, 1909. (Discusses the relative advantage of brick and concrete; 3,000 words.)

"Eisenbetonrohre mit bewehrten Fugen." Zeitschrift für Transportwesan und Strassenbau 1909, No. 4, p. 70. (Illustrated.)

"Eisenbetonrohren mit Eisenbetonverbindung." Fördertechnik, 1909. No. 3, p. 73.

"Röhren aus Beton." Betonzeitung, 1909, No. 25, p. 489.

"Zementröhren mit Drahteinlage." Architecktenzeitung, 1909, No. 24.

"Zementröhren." Betonzeitung, 1909, No. 40, p. 786.

"Experience with Concrete Water Mains at Rahway, N. J." Concrete, 1910. No. 8, p. 42, illustrated.

"Wie stellt man Cementrohre Wasserdicht her?" Kunsstein-Industrie, 1910, No. 3, p. 55.

"Platten-Kanal aus Eisenbeton," by K. Eschenbrenner. Zeitschrift für das Baugewerbe, v. 5, No. 54, p. 36.

"Die Formgebung für geschlossene Kanäle aus Eisenbeton," by M. M. Sudd. Bauhütte, 1910, No. 1, p. 2.

"Wie verhalten sich Zementrohre gegenüber der Entwirkung von Säuren bezw. saurehaltigen Abwassern? by H. Hell. Betonzeitung, 1910, No. 7, p. 127.

"Die Herstellung Grosser Kanalisationsrohre aus Stampfbeton." Betonzeitung, 1909, No. 50, p. 985.

"Wasserrohre aus armiertem Zement-beton." Betonzeitung, 1910, No. 12, p. 241.

"Zementbetonröhren," by Fr. Wendt. Zement und Beton, 1910, No. 8, p. 115.

"Verfahren Zementrohre mit Glaseinlage herzustellen." Betonzeitung, 1909, No. 51, p. 1008.

"Verfahren, Zementrohre mit Glaseinlage herzustellen." Zement und Beton, 1910, No. 6, p. 94.

"Zementröhren und Beton zu Kanalisations-Zwecken." Blatt für Wasserbau, 1909, No. 29, p. 449.

"Reinforced Concrete Pipe for Sooke Water Supply." Western Engineering, Sept., 1914. (Describes method of constructing a 42-in. conduit, including a pressure syphon.)

"Uber Verwendbarkeit von Zementröhren beim Bau von Kanalisations-undBrunnenanlagen," Fritz Bergwald. Des Strassenbau, 1911, No. 20, Jan.

"Beton Bei Kanalisation-und Reinigungsanlagen," Baumaterialienmarkt, v. 11, 1912, No. 51, p. 1352.

"Berechnung eines Beton Kanals." Z. Tiefbau, v. 8, 1912, No. 16, p. 188.

"Ueber Verwenbarkeit von Zementröhren," by Fritz Bergwald. Städtische Tiefbau, v. e, 1912, No. 20, p. 317.

"Ueber das zweckmässige Alter von Zementröhren und Betontreppen bis zur Verlegung," by P. John. Ost D. Bauztz, v. 11, 1913, No. 10, p. 57.

"Berechnung eines Betonrohrdurchlasses." Zeitschrift für Tiefbau, v. 9, 1913, No. 5, p. 41.

"Value of Concrete Pipe for Public Sewers," by G. Kaufman. Concrete, v. 12, No. 6, p. 46. (The contents of the paper are based on experience in Brooklyn, N. Y., where about 400 miles of concrete sewer below 24 in. in diameter, have been laid in a period extending over 50 years.)

"Misstände bei Kanalröhren und Vorschläge zu deren Verhütung," by Jul. Barth. Stadtische Tiefbau, v. 2, 1911, No. 13, p. 191.

"Zementröhren, ihre Eigenschaften und Verwendung zur Kanalisation," by H. Peris, Wasser-und Wegebau. Zeitschrift, 1911, No. 15, p. 169.

"Beton-und Eisenbetonröhren." Zentralblatt Wasserbau Wasserwirtschaft, v. 6, 1911, No. 13, p. 196.

"Beton-Röhren." Zentralblatt Wasserbau Wasserwirtschaft, v. 6, 1911, No. 11, p. 161.

"Wasserdicht gestampfte Behälter und Röhren aus Zementbeton." Baumaterialienmarkt, v. 10, 1911, No. 9, p. 247.

"Eisenbetonkanal in der Hafen-und Fleethörn-Strasse in Kiel." Zement und Beton, v. 7, p. 244.

"Wasserdichte Kanäle aus Zement-Kalkbeton," by Zantopf. Zement und Beton, v. 7, p. 786.

"Vorschriften über das Alter von Zementröhren bei der Anlieferung." Wasser-Wegebau-Zeitung, v. 9, 1911, No. 24, p. 295.

"Zementrohre," by Fr. Wendt. Zement Beton, v. 10, 1911, No. 40, p. 517.

"Reinforced Concrete Rainwater Culverts in the Reconstruction of Valparaiso," by T. P. Cliff. Concrete and Constructional Engineering, v. 6, 1911, No. 8, p. 591.

"Wasserdicht gestampfte Behälter und Röhren aus Zementbeton Deutsche Baukunst, v. 11, 1912, No. 14, p. 151.

"Armierte Betonrohre." Uhland. Prakt. Masch. Konstr. 1912, No. 20, p. 35.

DISCUSSION.

(Subject No. 10, Concrete Culvert Pipe and Piles.)

H. Rettinghouse:—Before reading this report I would like to mention a subject which is rather dear to my heart and I find from my conversation with several other committee chairmen, that the subject is equally dear to their hearts. I beg to refer to the preparation of committee reports and the difficulties which are experienced by chairmen in getting the proper co-operation from members of committees. I took the chairmanship of this very important committee partially under protest, but the president was so persistent and persuasive in his arguments to the effect that I should accept it that I finally though reluctantly consented. I made the condition that he should select such members on whom I could depend absolutely, not so much for assisting in the work of tabulating the information after receiving it, but for advice in regard to the methods to be followed for the purpose of securing the information on which the report was to be based. I addressed the members of the committee as soon as they had been appointed by the president, but I was then unable to get satisfactory advice, or even any reply whatever. The president will bear me out in this assertion, because I complained to him when I visited him in Chicago. It is of course understood in all cases that the chairman of a committee is the man who has to do the work, but if any member of this association is appointed a member of a committee, he should certainly understand that he should give all that is in him, in order to help make the report a success. I do not wish to have this appear as any personal criticism of the particular members of my committee, for I understand from others with whom I talked that they experienced the same trouble.

This report on Concrete Pipe and Piles required considerable thought as to investigation regarding the manner and method in which the information was to be gathered. Report had been made on the subject by a committee of the American Railway Engineering Association, and while we found we would be able to use some of the information contained within their report, we thought later on we could elaborate on it so as to make it more complete. Because of the delay in getting the question sheet prepared our information necessary for the tabulation of the practices of the various roads was very much delayed and the report presented in printed form is not complete. We have made a tabulation of concrete pipe practice which shows the replies from a great many railroads; this information will be printed as an appendix to this report.

G. A. Manthey:—We have used concrete culvert pipe quite extensively for the past 5 or 6 years with very good success, the sizes running from 18 in. to 60 in. in diameter. Where we have large drainage areas we install 2 or 3 lines of the larger sizes. We have also, during the past year, installed 16 or 17 concrete cattle-pass culverts as shown in one of the illustrations in connection with this subject. These culvert pipes are oval in form, the height being 89 in., and the width 84 in. They are built in 6 ft. lengths. The cost of the pipe is $12 per lin. ft., and the placing averages $7.50 to $8 per ft., according to the location. This includes installation of everything complete—wing walls, etc.

Our concrete pipe is built by contract by the C. F. Massey Co., at our Shoreham Shops at Minneapolis, and is loaded on cars and shipped out by them to points along the line where it is to be used. We make it a point to make shipments of the large size cattle-pass culvert pipe for a specified district at one time when we make use of a wrecking derrick for unloading, which reduces the cost of handling and enables us to place them to the best advantage for installing. These cattle-pass culverts are quite satisfactory in every respect.

H. Rettinghouse:—By examining very closely you may see the corrugated surface at the bottom of the pipe of one of these cattle-passes.

A. S. Markley:—I would like to ask, in placing concrete pipes, whether it is the practice to cement the joints? We found in using iron pipe that it is an advantage to calk and cement the joints, so as to make the spigot end as secure as the bell end; otherwise there is a tendency to break. From our experience in rolling iron pipe off cars we always let the spigot end drop on the ground first; the other end, being the bell end, is not so likely to break, especially in the case of large pipes, and I presume the same rule would apply in handling concrete pipe.

H. Rettinghouse:—The definition as to practice which will be shown in the tabulations gives that information. Here is a column headed, "Are Joints Cemented or Not?" and the various railroads answer and give reasons pro and con.

A. S. Markley:—There is another advantage I failed to mention,—it prevents the pipe pulling apart. We have had iron pipe pull 4 and 5 in. out of the bell by the bulging of the bank; and if the bank is new it is more likely to break than under well settled banks.

The President:—Mr. Sinclair can tell us something in regard to placing concrete pipes under new fills.

E. L. Sinclair:—One precaution we took in laying the pipe was to allow the fill to settle and to take the weight direct until the settlement was completed so that there would be created an arching effect of the bank. We put in struts or vertical supports, wedging them tightly at frequent intervals through the pipe and maintaining them until the bank was thoroughly settled, after which they were knocked out. I found that the Massey pipe was more difficult to handle than pipe without a projection for the bell. You will notice in the picture of the Chicago, Milwaukee and St. Paul pipe that it is the same size throughout (without any bell). It is, of course, much easier to roll a pipe of that uniform size than one with the enlarged bell. Where we were moving pipe some distance between the old and new tracks on new double track construction work, we laid down two lines of stringers to roll the pipe on so that the bell would be kept off the ground, and found that this worked very well. The pipe usually came setting on flat cars on the bell end and we used a derrick to unload them.

R. H. Reid:—We have used and are still using a 60-in. by 66-in. reinforced concrete pipe on the New York Central under various conditions which require pipe of that size. That is the only size of concrete pipe that we are installing now. We make these ourselves, elliptical in shape, with the vertical diameter greater than the horizontal. In placing the pipe it is necessary to set them rather carefully so as to get the full benefit of the reinforcement. To insure this, we make a 2-in. hole in the top of the pipe in the center, and have an eyebolt passing through that and through a timber which can be fastened to the hook of the derrick. Our sections are made in 6-ft. lengths and weigh about 7,000 lbs. each. We do not roll them off the cars when unloading, but we lift them off and put them in place with a derrick. We have had no trouble, have found no breaks or cracks in any pipe installed, and have had very little, if any, trouble with their pulling apart, although I think cementing the joints is desirable where it can be done. In most cases it has been practicable for us to cement the joints. In a few cases we have used old rope to calk the joints where we encountered fine sand and water, and where there was danger of the bank running through the cracks and causing difficulty under the track.

Years ago we had a good many elliptical concrete culverts under the track, of 20 to 30 in. vertical diameter, and probably 16 to 24 in. wide, made flat on the bottom. I understood that these were intended to be placed on plank or old bridge stringers, to hold them in line and grade until the bank could pack firmly around them. I do not know whether they were all placed on the plank or timbers, but a good many have crushed and have been taken out and replaced with iron pipe. My impression is that in the case of most of these pipes which have failed, it was not the fault of the concrete, but it was either the result of faulty installation or careless filling in over it. I think that in some places rocks may have been dropped on them and in other places they may have been set over pile stubs and similar conditions which caused unusual stresses in the concrete and caused them to crack. Many of those pipes which cracked perhaps within 1, 2 or 3 years after they were installed have stood up under traffic for 20 years afterwards. Some of them are still in use with no change in their condition since the time the original cracks were formed, 10 to 20 years ago, and those which have been taken out were removed on account of special conditions. We had two brands of pipe, one made at South Bend and the other at Lansing. The pipes made at Lansing were about as hard as flint, and while some of them cracked, probably due to faulty installation, the concrete itself was as good as any I ever saw. I think that if these pipes had received even reasonably fair treatment in being placed they would have been good for an indefinite period.

J. S. Huntoon:—We use concrete pipe up to 72 in. in diameter. The 5-ft. lengths are made circular with two lines of reinforcement. We have not had any trouble with them. The joints are caulked with cement. We did have some pipe on our Canada division which have nearly disappeared, having cracked and gone down. There was no reinforcing whatever in these.

H. Rettinghouse:—I want to call the attention of the last speaker to the report received from the chief engineer of the Michigan Central, which would rather contradict his statement; it is incorporated in this paper, showing that the Michigan Central uses reinforced concrete pipe of the Massey type.

J. S. Huntoon:—Well, it is of our own special design, but made by the Massey Co. It is a reinforced pipe. We have used some of the Massey standard pipe and it has been under the track, but this is not the general practice.

A. H. King:—I don't doubt but that a concrete pile is a good thing, but I am a little in doubt as to the manner in which the cap is applied. I would like to secure some information regarding that. In other words, piling, if properly driven or placed, will be put down to a point where they will get a bearing and will be fairly permanent, but that might leave the tops at varying heights. I would like to get some information regarding the manner of application of the cap. In driving a timber pile, the usual practice is to drive it down until it secures a bearing; in other words, until the pile is solid. That may be more or less, for different piles in the same tier may go down to different depths. With wood we can cut them off with a straight edge to a perfect line and apply the cap, but when you drive the concrete piles I assume that they will not be of a uniform height and will have to be cut off to some line. I wish to know the manner in which that is done to apply a cap.

H. Rettinghouse:—The cap is moulded on after the piles are driven; you will notice in the report a photograph of a concrete pile bridge of the Illinois Central, showing various thicknesses of caps, indicating in some places it was necessary to bring the cap down lower than at other places on account of variation in the heights of piles.

The tabulation contained in this report will give the desired information regarding the practices of various railroads, the type of hammer used and the kind of driving cap.

A. H. King:—It seems to me that the cap might be possibly two or three feet deep as if that was intended to overcome any unevenness in the pile.

H. Rettinghouse:—Yes sir.

A. H. King:—But, assuming that some of the piles would strike a rock and others would miss it and go down in a soft place, there might be differences greater than those indicated in this illustration.

H. Rettinghouse:—Well, if you have a pile sticking up very high I should say that under ordinary circumstances you would be up against it.

C. W. Wright:—We use a great many of those piles and our practice is to use a pile two or three feet longer than required, and after breaking them off at the desired height the reinforcing rods are moulded into the cap.

E. L. Sinclair:—In connection with second track construction, we built quite a number of concrete pile bridges, and we endeavored to determine as nearly as possible from the previous records of the driving of the old bridges the lengths of piles needed, so that when driven the piles would not vary more than a foot or a foot and a half in height, which variation would be taken care of by the moulded cap on top of the piles. Once in a while one would strike some obstruction in which case it is necessary to cut the pile off. That is the only way to overcome it; if you can't get the pile down, cut it off. We had very few cases where we had to do that. In nearly all cases we were able to drive the pile down to within the limit that could be taken care of by the height of the cap.

G. W. Rear:—It would not appear to me that it would be economical to use a concrete pile at all where the driving is very shallow. If one can find a rock foundation a few feet below the surface, he ought to excavate to it and build a crib or some reinforced type of bridge.

H. Rettinghouse:—Mr. Rear has raised the point that a concrete pile bridge, like any other, must be adapted to the local situation. We cannot put them in anywhere, any more than we can any other kind of a bridge.

A. S. Markley:—About two years ago I investigated the driving of 24 ft. concrete piles for a ballast deck trestle about 1,000 ft.

long. A water jet and a 2,800 lb. drop hammer were used to sink the piles. Common jute sacks (used in bailing waste) were placed on the heads of the piles for cushions. I saw several driven. The blows from the hammer did not appear to damage the heads of the piles to any great extent. The damage done was simply that of spalling the corners of the piles at the top not to exceed 1 or 2 in.

R. C. Sattley:—I should say that wherever there was a suitable foundation within a few feet of the surface we should build a pier in place of a pile bent and use the concrete piles only where it would have been necessary to drive foundation piles to set the pier on.

E. F. Gardner:—I have been very much interested in the Lehigh Valley terminal piles at Buffalo. They were octagonal in shape, from 32 to 40 ft. long and about 16 in. through, and were all driven with a jet and steam hammer. I have stood by the driver and seen a pile take 350 blows of the hammer. In some cases the piles had to be cut off before they reached the solid rock owing to some obstruction, and in those cases they cut the tops off and turned the reinforcement over as a method of attaching to the pier when the pier was placed on the pile. I think they drove some 3,500 or 4,000 piles. The entire terminal on Scott street and facing Main street was placed on concrete piles. They manufactured the piles themselves in the yard at Buffalo, using a 1 to 3 mixture.

F. E. Schall:—The terminal that the gentleman spoke about is located over a place where there is soft muck and nothing to hold onto except the rock. The rock had been tested out by borings. We first contemplated driving wooden piles, but for fear the ground water conditions might change we changed to concrete piles about 20 in. in diameter and 30 or 40 ft. in length. The bearing had to depend on the depth of the rock; some drove down, while others stuck up 8 or 10 ft. Obstructions were found here and there, in the shape of old walls. An old canal also runs through there, but piles can be jettied easily on account of the soft material. We had no particular difficulty in cutting off the piles. I don't think it takes as much money as for wooden piles. They are all driven by steam hammer and jet. I think I saw one that had taken 300 blows where they had found an old dock wall and the pile was sliding around. Most of the piles went down very rapidly.

(SUBJECT No. 11.)

PROTECTION OF GRADE CROSSINGS.

REPORT OF COMMITTEE.

Because of the danger of accident at grade crossings of railroad tracks and public highways, all railroad officers and other persons interested in public safety are gratified to observe the trend of public opinion and the progress being made toward the elimination of grade crossings. We note with approval press reports that officials of San Bernardino, California, have filed with the State Railroad Commission applications to close two grade crossings over tracks of the Atchison, Topeka & Santa Fe at points where accidents have occurred, which is the inauguration of a campaign to eliminate dangerous railroad crossings in San Bernardino county. There are of necessity many crossings of roads over the tracks of every railroad at which local conditions prohibit the separation of grades by reason of physical difficulties or of the excessive cost involved. Where a grade crossing must be maintained it is incumbent upon the railroad company to supply the most complete form of protection, and by so doing promote public safety and avoid the losses due to damage judgments granted by courts to injured persons.

It is the tendency in these times for civic, county or state authorities to demand of the railroads the form of crossing protection which in their judgment is best suited to the conditions, whereas with their experience the railroad officers may be able to install a superior device at less expense. It is thus desirable that we study all forms of crossing protection and by constantly observing conditions at crossings be prepared to install the protection best adapted to each particular case, and forestall demands of public authorities for specified devices.

All public crossings should be marked by crossing signs placed as conspicuously as possible to indicate the proximity of tracks. This is essential even though flagmen may be on duty, a bell ringing, or other warning given to drivers of approaching vehicles. The Southern Pacific standard highway crossing sign is a cross set on a post, painted white and lettered in black " Railroad Crossing—Look out for the Cars." A whistling post should be placed on the engineer's side of the track a quarter of a mile from the crossing so that trains may give warning of their approach. To further indicate to drivers of vehicles and trainmen the locations of crossings the cross fences should be painted white or whitewashed. These practices need not necessarily be applied to all farm crossings, but there are cases where it is proper to be so governed.

It is important that the roadway at railroad crossings be kept in good condition. Even in cases where it is only incumbent on the railroad to maintain the roadway between its rails and for two feet outside the necessary steps should be taken to see that the approaches are maintained on easy and uniform grades, and free of ruts or rough spots which might possibly stall an automobile, or otherwise contribute to hazard at the crossing. The area between the rails should be kept well filled, and if a smooth crossing can not be obtained otherwise guard rails should be used.

Objects which obstruct the view of crossings either from approaching trains or vehicles should be removed as far as possible. Whatever protection may be provided at a crossing will be inefficient if the view from all directions is obscured by trees or other obstructions. Proper care in this respect may greatly reduce the hazard of accident.

The choice between the forms of protection in common use lies between gates, wigwag signals or so-called automatic flagmen, and flagmen. There is no rule for determining the choice of protection, but the best device may be indicated by local conditions of topography, the widths and layouts of roads or streets, the angle of crossing, etc., or it may be chosen after experience and observation of a particular case.

Crossing gates are suitable for roadways crossing one or two tracks where the traffic is not greatly congested. Where the teams are very numerous, the time required to operate gates tends to block the traffic and create congestion. There is the further possibility of vehicles being caught between the gates or of the gates being lowered on them. Where the roadway crosses a large number of tracks gates are least satisfactory. There are cases of well improved highways in suburban or country districts where automobiles are run at high speed where gates are sometimes run through. In an article in the Railway Age Gazette of July 16, 1915, a crossing is described and illustrated where the ordinary light gate has been replaced by a spruce pole about ten inches in diameter as an effective barrier against automobilists who approach the crossing at reckless speed. This gate is painted with spiral bands of black and white to attract attention at a considerable distance. The Southern Pacific has tried red paint and stripes on its crossing gates, but a subsequent canvass of automobile drivers indicates a preference for plain white gates as being easier to distinguish especially at dusk or dawn. In the opinion of the committee white is the best color for gates.

There are various types of gates, wire-pull, electric and pneumatic, all having the same idea of placing a barrier across the roadway. Some have ticklers and others fence attachments but these are but variations of the barrier idea. There is also in use an automatic gate which is operated in a manner similar to automatic signals. This we do not approve, as it has not been found satisfactory as yet. It is apt to lower on a vehicle, or if constructed too high to strike a wagon is too tempting for malicious persons to tamper with it.

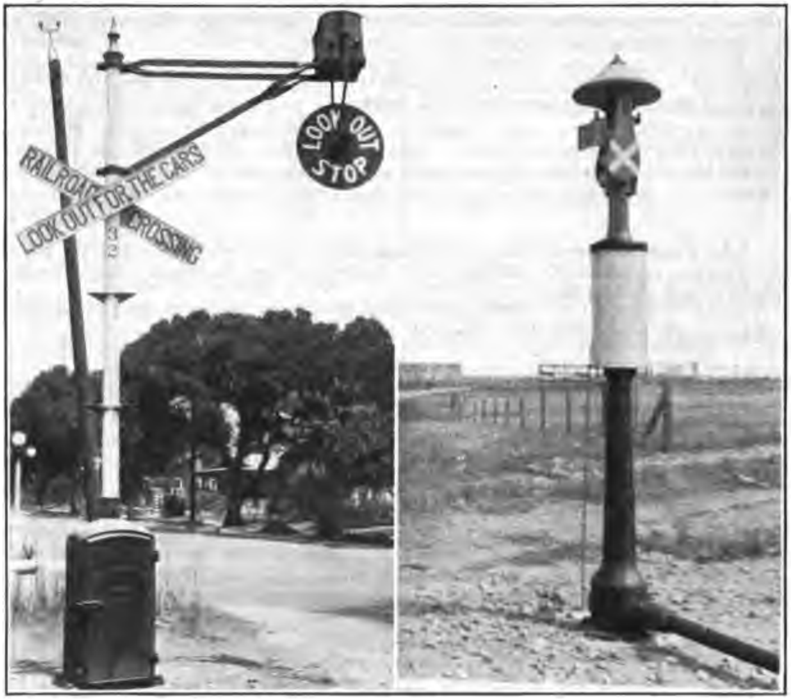
A very good additional protection in connection with crossing gates is a red light hung on the gate at night, with blinders on the sides so that it will not be visible to the engineers of approaching trains. This light is replaced during the day time by a red disc.

As instances of busy and congested crossings which are protected by flagmen or crossing gates we cite First street, San Jose, Cal., at which point flagmen have superseded gates because of the congested condition of the crossing when the gates were in operation. Travel at this crossing is:

	6 A. M. to 6 P. M.	6 P. M. to 6 A. M.
Bicycles	940	382
Pedestrians	1070	1195
Automobiles	835	532
Wagons	955	305
Street cars	260	227
	4060	2641

At University avenue, Palo Alto, Cal., where the crossing is handled by gates the travel is:

	6 A. M. to 6 P. M.	6 P. M. to 6 A. M.
Bicycles	915	127
Pedestrians	912	242
Automobiles	315	55
Horse vehicles	531	50
Street cars	86	42
	2759	516



Electric Wig-wag Highway Crossing Signals.

Disc Highway Crossing Signal.

At Monterey Road crossing in Watsonville Junction yard where the road crosses five tracks protection is given by flagmen. At this point the travel is:

	6 A. M. to 6 P. M.	6 P. M. to 6 A. M.
Automobiles, bicycles and motorcycles	232	79
Pedestrians	109	52
Horse vehicles	275	45
	616	176

At Fourth street, San Francisco, there are two crossings of 26 and 30 tracks respectively which are protected by flagmen, the travel at each being as follows:

	6 A. M. to 6 P. M.	6 P. M. to 6 A. M.
Automobiles	370	14
Teams	1015	23
Pedestrians	1735	178
Motorcycles	6	
	3126	215

From the above tables it is seen that flagmen handle very heavy traffic while medium traffic crossing with a small number of tracks is best handled by gates.

The Southern Pacific is conducting experiments with a form of warning signal consisting of a red disc 16 in. in diameter located 200 ft. from the crossing. As automobile associations are providing signs which serve the same purpose it is perhaps better for railroad men to look out for the immediate crossing only.

Where traffic conditions do not require gates or flagmen the best form of signal is the automatic flagman or wigwag, which consists of a red disc displaying a red light at the center which is suspended from a bracket away from the line of poles as shown in an accompanying cut. The disc and light swing through an arc in the lower quadrant and attract attention readily from the roadway for a considerable distance. In some respects this device is superior to a flagman. There is no variation in the signalling. The movement is always the same. When in motion it can indicate but one thing,—that a train is approaching. A bell may be rung in connection with the visible signal, and this is advisable in certain districts; but in residential sections, where trains are numerous or where the signal may be operated for long periods on account of switching movements the bell may be removed and the device used as a visible signal only. The cost of installation of the wigwag varies with the number of switches within the limits of the electric circuits, the presence of automatic signal circuits, etc. The minimum cost is approximately $60 for labor and $260 for material, or a total of $320. On account of other circuits and switches within the operating limits of the signal the cost may reach as high as $500.

No matter what the railroads may do in the way of eliminating danger at grade crossings their efforts are of little avail unless the public coöperates to the extent of observing warning signals set up for its protection. The Los Angeles division of the Southern Pacific made a check at Ninth & Alameda streets, Los Angeles, with the following results: During a period of two hours 156 motor driven vehicles passed over the crossing. Of these

5.1 per cent looked both to the right and left.
6.4 per cent looked to the left only.
15.4 per cent looked to the right only.
73.1 per cent looked in neither direction and paid no attention to the crossing.

Pomona, Cal., causes the arrest of persons who disregard the city ordinances which require the drivers of vehicles to stop before crossing a railroad track. This is a very important step in promoting safety at grade crossings. With the Safety First movement sweeping the land the idea of caution at grade crossings should be hammered home by every bridge and building man and all other railroad employees in the interest of public safety. A personal way of checking up careless drivers is for gatemen or flagmen to note the vehicle numbers and write to owners and employers. It is our experience that employers are glad to be advised of instances where their employees show carelessness in crossing tracks.

Conclusions.

1. Obscure crossings should be opened up to the view as much as possible by the removal of trees, buildings, brush or other obstructions.
2. Roadways at track crossings should be maintained in the best possible condition.
3. An automatic flagman, gates or flagmen should be provided as local conditions may require.
4. All means possible should be used to induce the public to use caution at grade crossings.

E. C. Morrison,
A. T. Mercier,
F. M. Nelson,
A. Ridgway,
J. B. Gaut,
J. H. Johnston,
C. E. Johnston,
J. B. Sheldon,
G. H. Jennings,
F. O. Draper,
Committee.

DISCUSSION.

(Subject No. 11. Protection of Grade Crossings.)

C. E. Smith:—The subject of Protection of Grade Crossings brings forward a number of ideas that should appeal to all thinking men. A grade crossing is a mutual hazard, although a very necessary facility. The country could not have been developed so fast had it been necessary at the time of construction of railroads to have spent the additional amounts necessary to have secured separated crossings in the first instances. Grade crossings should be considered temporary expedients to tide over the period of development, and to be eliminated when increased traffic on rail or highway justifies.

It is to be hoped that when the railroads emerge, somewhat chastened, from the present epoch of anti-railroad sentiment and legislation, there may be a more united effort on their part in conjunction with the public officials to mitigate the evil of grade crossings.

The railroads that have earned fair returns have accomplished wonders along these lines and should be an object lesson of what the other railroads will do if permitted to earn an adequate return. In the meantime however the grade crossing will be always with us and will require the hearty cooperation of railroad and public to minimize its dangers.

The rough surface frequently encountered at a grade crossing taken in connection with bad approaches and restricted view has brought much condemnation on the railroads and has undoubtedly been responsible for much of the agitation for grade crossing elimination. Much of this agitation can be avoided by more attention than is usually given to such features and although this may mean somewhat increased expenditures at first the final result will be a great saving. A smooth crossing, with an easy approach on which vehicles, especially automobiles may stop and start with safety and certainty and reasonably free view does not impress itself upon the public mind as a great hazard and but little condemnation will be heard of such a crossing. A rough crossing with abrupt, steep, or narrow approaches, and obstructed view, will create the impression in the public mind that all grade crossings are a menace and will lead to demands for much elimination.

It is certain that if the public and the railroads will work in harmony and each show a disposition to share the expense on an equitable basis more rapid progress will be made. Crossings over busy tracks on much used city streets should be eliminated as the convenience of the public is entitled to equal consideration with the free movement of trains; the interests of both require the elimination of the hazard as fast as the problems can be worked out and funds can be provided to cover the cost.

For outlying crossings the situation should be met by suitable signs, warning devices, flagmen or gates, although combinations of these devices may be used at some places.

At isolated crossings not much used by either class of traffic a sign should be sufficient, but unless care be exercised by all concerned accidents will occur. The writer was a passenger on a train which became involved in a distressing fatal accident on the plains of western Kansas where highway and railroad were plainly visible for over a mile in all directions. A buggy with three children drawn by a single horse drew up to the crossing and after stopping to permit the train to pass, started across immediately in front of the engine, too late to stop the train. The horse and one of the occupants were killed, another was injured. Cause—the driver failed to exercise sufficient care in handling the horse.

Even where the traffic is light, if the view be obscured there should be an automatic bell or an audible signal. In the country where there are not many houses close to the track the noise of a loud bell will not bother anyone, but in well built up city and town districts the noises of such warning bells have caused much complaint and have brought about the development of the automatic visible signal as an alternate for or as an adjunct to the bell. Such devices, when properly maintained, afford absolute warning, but it is needless to say that they must be properly maintained under all conditions. They should be maintained with the same care and attention that is given to the maintenance of automatic block signals as the safety of persons depends as much on one as on the other.

The writer has been greatly embarrassed in public hearings by testimony that bells do not ring or that visible signals do not warn on the approach of trains or that the bells ring and the signals warn of danger continuously when there are no trains near. Manifestly an imperfect signal is worse than none at all as it is a decoy that leads to almost certain disaster. Automatic devices must be maintained at 100 per cent efficiency. When out of order a flagman must be stationed at the crossing until repairs are made. Even where automatic signals are maintained occasional speed maniacs will take chances in an endeavor to save a few minutes by racing across ahead of the train. Where the traffic is sufficiently heavy this must be guarded against by physical barriers such as flagmen or gates or both. Mutual care on the part of the public and the railroads will be necessary in spite of the warning devices. Conductors and motormen of street cars and drivers of automobiles are the worst offenders. The writer witnessed a conductor alight from a well loaded street car at a grade crossing and while still absorbed in conversation with the motorman, give him a signal to proceed while the gates were being lowered and a train was only a few hundred feet away. The first gate barely missed the trolley pole; the second gate dropped in front of the car. The motorman, realizing his predicament, turned on his power at full speed, broke through the gate, and cleared the train by a very few feet.

It must be recognized that the automobile is here to stay and will continue to increase in numbers. The power that drives an automobile, however ideal it may be in other respects, is very imperfect under conditions that may embarrass or excite the driver. The starting and stopping of an automobile depends upon the handling of several pedals and levers in prearranged order, and if the driver becomes rattled or has his attention distracted by an approaching train while he is in a critical position, any one of a number of false moves may advance him or stop him right in front of the train.

Railroads can not be insurers or guardians of careless, or unskillful or easily rattled automobile drivers, but the mutual hazard of grade crossings makes it necessary for railroads to throw every possible precaution around the danger points so as to reduce the hazard.

MANILLA ROPE.

By F. E. Weise.

Possibly there is no article in the outfit of a railroad construction organization or of a contractor, that suffers more neglect and abuse than manilla rope. In nine cases out of ten this condition is due more to a lack of knowledge than to wilful neglect. The object of this paper is to present a few facts regarding the manufacture, structure and qualities of rope that will lead to a better appreciation of its value. It is the general impression that the use of manilla rope is decreasing and that it is being replaced by wire rope, but this is true only along certain lines, and on the contrary, the field for its use is increasing.

Fibers from which ropes are made are termed by manufacturers as hard and soft. The hard fibers are of Manilla, sisal and New Zealand hemp, and the soft fibers are of jute, American hemp and flax. Of the hard fibers, very little New Zealand hemp is used. The best rope for all purposes is made from Manilla hemp, and very little rope over one inch in diameter is made from anything else. Sisal hemp is shorter and coarser than Manilla, is not as strong and will not withstand water or the weather as well. A considerable amount of rope less than one inch in diameter is made of sisal hemp. The soft fibers are used mainly for the manufacture of small rope and cord. The scope of this paper is limited to the best and larger ropes and, therefore, deals entirely with Manilla rope.

Manilla hemp is the product of the Abaca or Lanut plant, a native of the Philippine Islands, and is shipped from there in large quantities. It is the best fiber for rope making that can be had because of its great tensile strength. Its use is confined to the manufacture of rope because it is not flexible enough for twine or cord. There are many grades of Manilla hemp and also a great difference in the quality of the different grades. The quality of the rope depends, therefore, on the quality of the fiber used in its manufacture. It is rather difficult to determine differences of quality by an inspection and test of new rope, and a safe course is, therefore, to purchase rope for bridge and building work from reputable manufacturers.

Although the production of hemp has greatly increased, primitive methods of extracting the fiber are still used. The leaf petioles or stalks are separated from the plant and stripped by hand by drawing them between a knife and a block of wood, thereby extracting the pulp and waste from the fiber. The fibers, which vary in length from 6 to 12 ft. or more, are then separated into different grades, based on color, strength, fineness and length. The ruling factors are coarseness and strength.

An examination of the fibers under the microscope shows that they are composed of elongated cells. They are very strong in the direction of their length, but rather weak transversely.

Until rather recently all rope was made by hand, but its manufacture has been revolutionized by the introduction of modern machinery. In a modern plant the bales of fiber are opened and graded as to quality by expert workmen, and are then passed to machines where the fibers are reduced to suitable size for rope making. After this operation the fiber is spun into yarn by twisting it in a right hand direction. From 30 to 75 yarns, according to the size of the rope, are put together and twisted in the opposite, or left hand direction, into a strand. Three or four of these strands are then twisted together in a right hand direction into a rope. In the manufacture of a very large rope or cable, three hawsers or three strand ropes are twisted together in a left hand direction. It will be noted that each operation is in an opposite direction, and because of this the rope keeps its form. The rope maker has learned by long experience how to make these twists so that the tendency of one part to untwist will cause another part to twist until an equilibrium is attained. If the twist is great, the rope will be hard and stiff and will keep its form well, but it will not be as strong as a rope with less twist. This is explained by the fact that in the latter case the fibers lie more nearly in the line of tension.

Terms Used in Connection With Rope.

Yarn—Fibers twisted together.
Thread—Two or more yarns twisted together.
String—Same as a thread but with larger yarns.
Strand—Two or more large yarns twisted together.
Cord—Several threads twisted together.
Rope—Several strands twisted together.
Hawser—A rope of three strands.
Shroud-laid—A rope of four strands.
Cable—Three hawsers twisted together.

The following data found in some notes made several years ago is good information for the purchaser of ropes.

"A good hemp rope is hard but pliant, yellowish or greenish gray in color, with a certain silvery or pearly lustre. A dark or blackish color indicates that the hemp suffered from fermentation in the process of curing, while brown spots show that the rope was spun while the fibers were damp, and it is consequently weak and soft in those places. Sometimes a rope is made of inferior hemp on the inside, covered with yarn of good material. This may be detected by dissecting a portion of the rope. Other inferior ropes are made from short fibers, or with strands of unequal lengths or unevenly spun, the rope in the first place appearing woolly, on account of the ends of the fibers projecting. In the latter case the irregularity of manufacture is evident on inspection.

"A test for ascertaining the purity of Manilla hemp rope consists in forming balls of the loose fiber of the ropes to be tested and burning them completely to ashes; pure Manilla burns to a dull grayish-black ash; sisal leaves a whitish-gray ash; a combination of Manilla and sisal yields a mixed ash resembling the beard of a man turning from black to gray. Manilla hemp is frequently adulterated with phormium (New Zealand flax) and Russian hemp both of which are much inferior in strength."

It is not always true that the highest priced material is the best, and there are no doubt many cases where from lack of knowledge or time for investigation, a better grade of material is purchased and used than is necessary. The price of the material is governed largely by its quality but the selection of the quality should be governed by its suitability to the work in hand, and in the case of tools, to their future use. Nowhere is this more evident than in the selection and use of rope, and while it is difficult to judge a new rope, experience will soon make a careful observer a fairly good judge.

Rope in service deteriorates in two ways; the wear on the outer surface that can readily be seen and the stretching, bending, crushing and breaking of the inner fibers that can not be discovered without a careful examination. Should these conditions develop more rapidly than the service in which the rope is used seems to warrant, they may be due to the following causes: The first might be caused by chafing, resulting from ropes rubbing against each other or dragging across hard materials or by their running over sheaves having too small a groove. The latter may be due to overload or to running over sheaves or pulleys of too small diameter.

Ropes do not give out all at once and, therefore, need much care and attention. The factors that determine the usefulness of a rope and its length of service or life are; the material of which it is made; the care and skill with which it is manufactured; the manner in which it is used or its application and the care taken of it while in service and while being stored.

Manilla hemp is a vegetable fiber and is susceptible to the action of water and air the same as an unprotected piece of wood. In fact, the hardest wear on a rope is exposure to all kinds of weather. This can not be avoided in construction work, therefore, when a rope has become wet and muddy, it should be cleaned, dried and stored in a well-ventilated place. Wet rope placed in a box or in an unventilated storeroom is likely to rot or ferment and will become worthless in a short time. Ropes that must necessarily be constantly exposed to the weather are tarred frequently, but as the tar affects the tensile strength, it can not be used on ropes that are subject to hard use on derricks and cranes. Tarred ropes may be used for guy lines, the rigging of ships or similar work.

It is generally conceded that moisture will not injure a rope in storage provided the storeroom is well ventilated and in fact some dealers advocate a damp storeroom. On the other hand a rope may be seriously injured by becoming too dry, because the fibers become brittle. A rope should not be allowed to freeze after becoming very wet, or if frozen, should not be used because the frozen fibers will break and thus make it useless. Neither should rope be piled against radiators or steampipes for obvious reasons.

The failure of ropes is more likely to be due to overloading than to any other cause. Should a rope be submitted to an overload, it may be shown by the twist coming out of it, or by one of the strands slipping out of its proper place. In the handling of heavy loads with a derrick or crane, the load should never be applied suddenly or with a jerk, not only because the stress will be many times that of the weight to be lifted, but it will also cause deformations in the rope that start deterioration. Should there be a kink in the rope, the damage may be serious enough to cause failure. In any event, the rope will have lost much of its strength and value. Apply the power slowly and uniformly, and it will not only give one better service from the ropes, but from the machinery as well. Ropes used on derricks, cranes and pile drivers wear out very rapidly. It is said that a rope 1½ in. in diameter will wear out in handling from 7,000 to 10,000 tons of coal, while a transmission rope of the same size running 5,000 ft. per min. and carrying 1,000 h. p. over sheaves 5 ft. and 17 ft. in diameter will last for years.

The rapid wear of ropes used on derricks and pile drivers is due to the rope passing over comparatively small sheaves under load. When over a sheave, the fibers next to the sheave are under compression while on those on the opposite side of the rope the tension is increased. Then as the rope straightens out the condition changes; the compression on the inside changes to tension and the tension on the outside is somewhat lessened until the tension on both sides of the rope is the same. This is clearly shown in one of the illustrations. This causes the fibers to slide slightly on each other and as they are somewhat rough, the friction ultimately causes them to break. Frequently upon opening up ropes of this kind, it is found that some of the inner fibers have been ground to a fine powder. Manufacturers aim to overcome this difficulty by treating the fibers with tallow or graphite or both, but there seems to be considerable difference of opinion as to the value of such treatment. Tallowlaid rope is not affected as much by weather conditions as rope not so treated. Should it be necessary for a rope to run over two sheaves, bending it first in one direction and then in another the difficulty last described is much exaggerated, and is much like bending a pliable wire first one way and then the other. It will soon break.

All this goes to show that on construction work satisfactory service can only be derived from the best quality of rope and it should be carefully selected. The New York, New Haven & Hartford has specifications governing the purchase of manilla rope which are given as an appendix to this paper.

It is frequently necessary to splice the ends of two ropes together in order to make one long rope. Either the short splice or the long splice may be used. The short splice, if properly made, will develop the full strength of the rope, but can not be used over a sheave because it is considerably thicker than the original rope. The long splice can be used over a sheave, but it can not be expected to give as good service as an unspliced rope. The short splice is more quickly made.

Manilla rope is usually supplied to the storekeeper in coils of 1,200 ft., and is shipped out by him in lengths suitable for the work. The shorter pieces left over are used for making slings. After it is worn out, rope is returned to the storekeeper as scrap. The accumulation is disposed of from time to time by selling to scrap dealers at a price approximating $50 per ton.

The writer received numerous interesting replies to his inquiries and they all helped to build up this paper. A contractor writes:—" Rope is a vital issue with us and it is with every contractor. It is more abused than any other article used in our line of business." A supervisor of bridges and buildings says:—" a common neglect is allowing rope to run over the sharp corners of timber or steel while in motion, causing friction, heat and unnecessary wear; proper organization and discipline will increase the life of a rope 100 per cent."

The practice on different roads varies considerably as to the sizes used for different purposes. Pile lines are usually 1½ in. in diameter; hammer lines vary from 1½ in. to 2 in. and various kinds are recommended, some using transmission rope, some tallowlaid, and so on; ropes for swing staging for painting bridges, stacks and buildings are ¾ in. or 1 in., and single and double blocks are used, depending upon the number of men on the staging and the height; ropes used in block and tackle for handling heavy material and machinery vary from 1½ in. to 2½ in.; guy lines are usually ¾ in. or 1 in.; one-inch rope is used for ordinary bridge work, and 1¼-in. rope for well drilling.

Slings made from Manilla rope for handling and hoisting heavy materials do not always receive the care and attention that they should, largely because of a lack of knowledge of what they will stand. Many advocate the use of new rope, and this is without doubt the safe plan. A new rope, however, is too stiff and it is better where possible to use parts of a rope that have been limbered up by a day's service. There are others that advocate the use of old rope for this purpose. If this is done, care should be taken to select pieces that have not been overstressed or that have not been working over sheaves. An examination can easily be made by opening up the strands and if the inner fibers show deterioration, the rope should not be used for slings. Slings are made by splicing the two ends of a rope together, using usually what is known as the short splice. On construction work and during wet weather, slings are subject to severe usage. When muddy they should be thoroughly cleaned, preferably with a hose, before the mud has been allowed to dry. They should then be allowed to dry under shelter, but never in the hot sun.

When slings are sent to the tool car or toolroom for storage, they should be inspected carefully and such as are not fit for continued use should be discarded. Those in good condition should be hung on suitable pegs. Slings are frequently called for in a hurry and under such conditions there is not always time to make an examination, or it may be overlooked. It is well to be on the safe side, because the failure of a sling may result in serious injury to the workman and a fall of only a few feet may damage or utterly ruin a piece of machinery.

The method of attaching a sling to a load should always be delegated to a reliable and experienced man. Whether one or more slings are to be used will depend not only on the weight of the load to be lifted, but also on its shape. In placing a sling on a load, care should be used to see that the load is evenly distributed on the two sides of the hoisting hook and also that the turns of the sling do not overlap, thereby throwing an excessive stress upon one part of it.

Not long ago the Travelers Insurance Company published an interesting article in its monthly publication called The Travelers Standard and by permission a considerable portion of the paper is quoted because it very clearly outlines some points about slings that are not generally known or carefully considered.

"The stresses that are thrown upon slings and ropes vary a great deal with conditions, and they are often influenced to a marked degree by circumstances which the casual observer might consider trivial and unimportant. In particular, the inclination or obliquity of the sling, in those parts which lie between the supporting hook and the points at which the sling first touches the load, must be carefully considered, as this is a highly important feature in connection with safety. The men who have to deal with slings often know very little about this subject, and we therefore give a number of outline sketches which may help to make it clear. In order to fix the attention upon the effect that the obliquity of the sling has upon the intensity of the stress, and to avoid the necessity of qualifying our statements repeatedly so as to make allowance for the stiffness of wire cables and for other circumstances, we shall assume that the sling is perfectly flexible in all the cases shown in the sketches, and also that the load is symmetrical in shape and symmetrically supported, and that the branches of the sling (between the hook and the load) are equal in length and equally inclined. For simplicity we shall also assume that the total load that is to be supported is 2,000 lbs. in each case, in the first five diagrams.

"Under these conditions, if the ends of the sling are exactly vertical, as in Fig. 1, the stress on each of them will evidently be 1,000 lbs. If the ends are inclined, however, as shown in Figs. 2, 3, 4 and 5, the stress upon each of them will be greater than 1,000 lbs. in every case, and it will increase as the obliquity of the ends increases,—that is, as they become more and more inclined toward a horizontal position. We shall not undertake to explain this fact fully, but in brief we may say that the stress on each of the inclined ends must have a vertical component equal to 1,000 lbs., and as there must also be a horizontal component whenever the sling stands obliquely, the total tension in each of the inclined ends must always exceed 1,000 lbs.

"If the sling is of such a length that its ends, between the hook and the load, are inclined to the horizontal at an angle of 60 deg., as indicated in Fig. 2, the stress on each end will be 15.5 per cent greater than it would be if the ends were vertical, as in Fig. 1; that is, in Fig. 2, each end will be subject to a total stress of 1,155 lbs.

"If the ends of the sling make an angle of 45 deg. with the horizontal, as shown in Fig. 3, the tension on each of them will be 1,414 lbs.; and if they lie at a still greater obliquity, so as to make an angle of 30 deg. with the horizontal as shown in Fig. 4, each of them will be subject to a stress of 2,000 lbs. If the obliquity increases still further, the stress will also continue to increase, and in a yet more rapid ratio; and when the ends of the sling approach the horizontal position quite closely, the stress upon them may become very great indeed. For example, if the sling were so short that its ends make an angle of only 5 deg. with the horizontal, as indicated in Fig. 5, each end would have to support a stress of 11,474 lbs.

"These figures show very clearly the importance of giving careful attention to the inclination of the free ends of the sling. Men engaged in hoisting too often take it for granted that the tension on a sling is everywhere the same, and if the sling is strong enough to support the load in safety when the ends are vertical, they assume that it is safe to hook it around the load in any way whatever. It is plain, from what has been said above, that this is far from being the case. The sling should always be long enough to allow the ends to be at least as steep as shown in Fig. 3; or, in other words, the ends should never make an angle of less than 45 deg. with the ground.

"In lifting large plates of steel, or heavy castings of a circular shape, three-part slings are often used, as indicated in Fig. 6. In such a case the three parts of the sling should be substantially equal in length, and the points at which the sling grips the load should be selected so that the strain will be the same on each of the three branches, so far as this can be judged by the man in charge of the operation. If the load consists of a circular ring or plate of uniform section, this will correspond to making the points of contact equidistant around the edge; but if some part of the plate or casting has a heavy projection upon it, then two of the branches of the sling should be put nearer to this heavy region.

"The steepness of the ends of three-part slings should conform with the same principles that have already been outlined above in connection with slings of the two-part or usual type. Thus if the load weighs 3,000 lbs., and the three branches of the sling are exactly vertical, each branch will be subject to a stress of 1,000 lbs.; whereas if the load is still 3,000 lbs., and each branch of the sling makes an angle of 45 deg. with the horizontal, then the load on each branch will be 1,414 lbs., on account of the inclination. Similarly, if each branch of the sling makes an inclination of 30 deg. with the horizontal, and the total load is 3,000 lbs., each branch will be subject to a stress of 2,000 lbs.; and under the same conditions, if each branch of the three-part sling makes an angle of only 5 deg., with the horizontal, as in Fig. 5, then each will be subject to a stress of 11,474 lbs.

"The accompanying short table shows the way in which the stress changes in two-part and three-part slings, for various inclinations of the ends to the horizontal. The use of the table will be evident from what has been said above.

Effect of the Obliquity of a Sling.

Angle Between Sling and Horizontal.	Stress on Sling, Per Pound of Total Load.	
	Two-Part Sling (Figs. 1 to 5).	Three-Part Sling (Fig. 6).
5 deg.	5.737 lb.	3.825 lb.
10 “	2.879 “	1.920 “
15 “	1.932 “	1.288 “
20 “	1.462 “	0.975 “
30 “	1.0000 “	0.6667 “
45 “	0.7071 “	0.4714 “
60 “	0.5774 “	0.3849 “
90 “	0.5000 “	0.3333 “

"When the load to be lifted has sharp corners or edges, as is often the case with castings, and with structural steel and other similar objects, pads or wooden protective pieces should be applied at these corners, to prevent the slings from being abraded or otherwise damaged where they come in contact with the load. This is especially important when the slings consist of wire cable or fiber rope, though it should also be done when they are made of chain.

"To show the importance of protecting sharp corners where slings run over them, reference may be made to Fig. 7. The total load is here supposed to be 2,000 lbs., and as the ends of the two-part sling make an angle of 30 deg. with the horizontal, each of these ends is also subject to a tension of 2,000 lbs. This tension is exerted partly to hold up the load, but it also tends to draw the sling horizontally against the load, at the points indicated by the arrows; and if the sling is pliable, and is placed about the load symmetrically as shown in the illustration, it will press against the load, under the assumed conditions, with a horizontal force of 1,732 lbs. at each of the upper corners. This pressure may damage either the sling or the load, or both of them; and it is to prevent damage from this source, as well as from the direct weight, that the pads are recommended. Wooden corner-pieces are often provided, as shown in Fig. 8, for use in hoisting loads with sharp angles. If pads of burlap or other soft material are used, they should be thick and heavy enough to sustain the pressure well, and to distribute it over a considerable area, instead of allowing it to be concentrated directly at the edges of the object to be lifted.

"Slings should always be kept in good condition, and when not in use they should be stored in a place specially provided for them, and locked up. They should be in charge of an experienced man, who should be held responsible for their condition. The man charged with the care of the slings should give them out as they are needed, and always with due regard to the use to which they are to be put. In this way it is possible to guard effectively, against the workmen using slings of inadequate strength. All slings should be returned promptly to the official custodian, when they are no longer needed for the work for which they were given out. As an additional precaution, every sling should be provided with a small metal identification tag, which should be fastened firmly to it. The tag should give the maximum stress that the sling can safely withstand in use, and in the case of a chain sling it should also give the date of the last annealing.

"Small cards giving the weights of the materials handled, per cubic foot, will often assist the workmen in estimating the weights of the loads, and will thereby be conducive to safety."

Knots and hitches form a very interesting phase of this subject, but they are very numerous and it would take much time to describe them. The Buffalo, Rochester & Pittsburgh has a drawing entitled "Some Knots and how to make them" and kindly consented to its reproduction in connection with this paper. The drawing explains itself and will be of interest to those in charge of field work.

The writer takes this opportunity of expressing his thanks to those who have so willingly responded to his inquiries. If this paper has brought to the minds of the members of this association a better understanding of the value of rope the time spent in its preparation was not in vain.

The New York, New Haven and Hartford Railroad Company.
Department of Tests.

Specifications No. 104.

Manilla Rope.

1. Material:

All rope furnished under these specifications must be either Manilla rope or Manilla Bolt rope, and must be made from the best quality of pure long Manilla fiber, free from admixture of any other fiber. The rope must be 3 strand medium-laid unless otherwise ordered.

It is assumed that Manilla Bolt rope, which is to be used in marine service, is the same as Manilla rope, except that it is made of selected fiber and possesses a greater tensile strength.

2. Physical Requirements:

The physical requirements for Manilla and Manilla Bolt rope are as follows:—

		Manilla Rope		Manilla Bolt Rope	
	Nominal Size in Circumference in Inches.	Maximum Weight per foot in Pounds.	Minimum Tensile Strength in Breaking Pounds.	Maximum Weight per foot in Pounds.	Minimum Tensile Strength in Breaking Pounds.
6 thd.	¾	.019	620		
9 "	1	.025	1,000		
12 "	1-⅛	.037	1,275		
15 "	1-¼	.054	1,875		
18 "	1-⅜	.0625	2,100		
21 "	1-½	.075	2,400		
	1-¾	.104	3,300		
	2	.133	4,000	.125	4,400
	2-¼	.165	4,700	.158	5,200
	2-½	.195	5,600	.183	6,200
	2-¾	.225	6,500	.213	7,200
	3	.27	7,500	.254	8,400
	3-¼	.315	8,900	.3	9,800
	3-½	.36	10,500	.342	11,500
	3-¾	.42	12,500	.396	14,000
	4	.48	14,000	.454	15,500
	4-¼	.54	15,400	.513	17,000
	4-½	.60	17,000	.571	18,500
	4-¾	.675	18,400	.642	20,000
	5	.75	20,000	.713	22,000
	5-½	.90	25,000	.85	27,500
	6	1.08	30,000	1.02	33,000
	6-½	1.25	33,000	1.196	36,500
	7	1.47	37,000	1.392	40,000
	7-½	1.68	43,000	1,583	47,500
	8	1.92	50,000	1.821	55,000
	8-½	2.15	56,000	2.046	61,500
	9	2.43	62,000	2.296	68,000
	9-½	2.70	68,000	2.563	75,000
	10	3.00	75,000	2.85	82,500

3. Number of Samples:

A sample six feet long will be cut for test purposes from any part of each coil ordered. Failure of this sample to pass the requirements of these specifications will cause the rejection of the coil represented.

4. Dimensions:

The size of the rope will be determined by the circumference in inches and fractions of an inch, and will be measured by passing a small string snugly around the rope, the string to be cut at the point of intersection and then measured. Rope must be uniform in size throughout its length, and must not exceed the size ordered.

5. Workmanship and Finish:

Rope must be made in accordance with the best practice known to manufacturers. It must be of the required length, free from chafing or any other defects. Rope must not be loaded with foreign matter and must not contain more than 10 per cent of the weight of the rope of lubricant for internal lubrication..

6. Identification:

In all rope ordered for marine use there must be incorporated in each strand a blue thread so that such rope may be readily identified.

7. Ordering:

Rope will be purchased on the basis of the price per pound, and will be ordered as far as practicable in coils of 1,200 ft. or in half coils of 600 ft.

8. Shipping:

Rope must be shipped in coils securely tied and covered with burlap or similar material to prevent chafing or other injury during transportation.

Each coil must bear a tag showing the size and amount of rope, the railroad company's order and requisition numbers and the name of the manufacturer. This information may be stenciled on the burlap if desired.

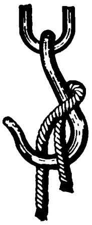
9. Inspection and Tests:

Rope will be inspected and tested either at the place of manufacture or after arrival of the material at destination. In either case the manufacturer must notify the engineer of tests of this company at least four days in advance of the time he will have the rope ready for shipment so that the inspection and tests are made at his works, if desired. If the inspection and tests are made at his works, the manufacturer must afford the railroad company's inspector such access to the works as will enable him to satisfy himself that the provisions of these specifications are being carried out. He must also furnish, free of charge to the railroad company, all test apparatus, test pieces and assistance necessary for the proper inspection and tests at his works.

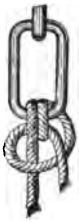
10. Rejected Material:

All rope which does not fulfill the above requirements will be rejected, in which case no reclaim will be allowed the manufacturer on any coil of rope that has been shortened by cutting off the sample for test purposes. If the rope is inspected and tested after arrival at destination and rejected, it will be returned to the manufacturer, who must pay freight charges in both directions.

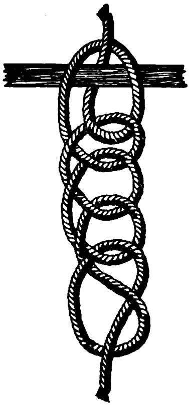
(Signed) E. H. Raquet,
Engineer of Tests.



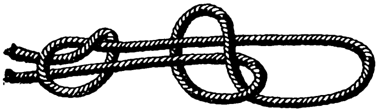
Blackwall Hitch



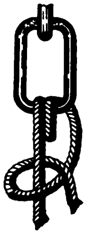
Fishermans Bend



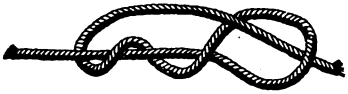
Chain Knot with Toggle



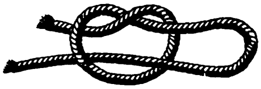
Flemish Loop



Round Turn &
Half Hitch



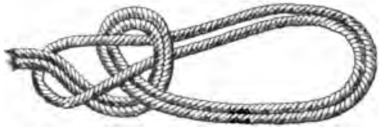
Stevedore Knot



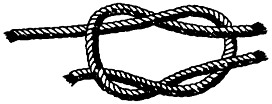
Slip Knot

B. R. & P. RY.
STANDARDS
SOME KNOTS AND HOW TO TIE THEM
Chief Engineer.

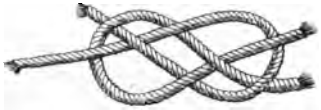
Revised Jan 1, 1914



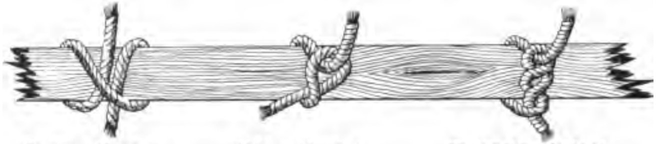
Bowline on a Bight

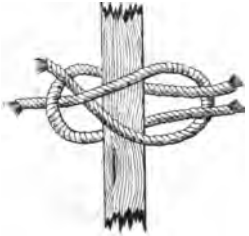


Reef Knot

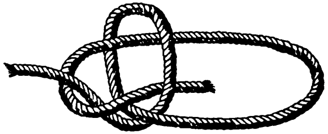


Carrick Bend

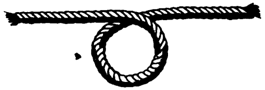




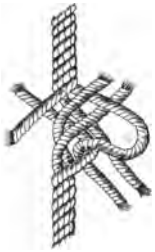
Weavers Knot with Toggle



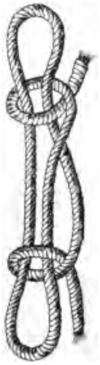
The Bowline



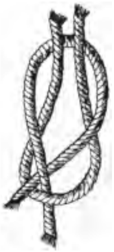
Bight of a Rope



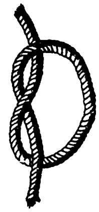
SHORT SPLICE



SHEEP SHANK



WEAVERS KNOT



SIMPLE KNOT

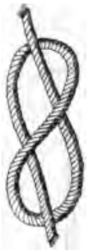
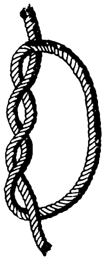
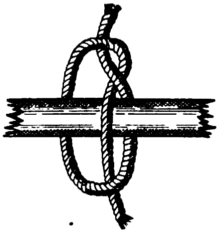


FIGURE EIGHT KNOT



DOUBLE KNOT



BOAT KNOT

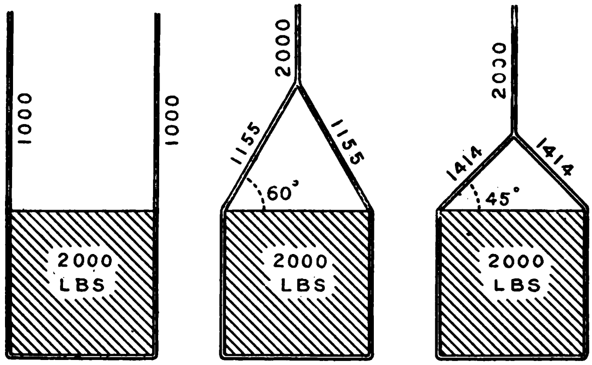


Fig. 1. Fig. 2. Fig. 3.

Illustrating the Obliquity of Slings.

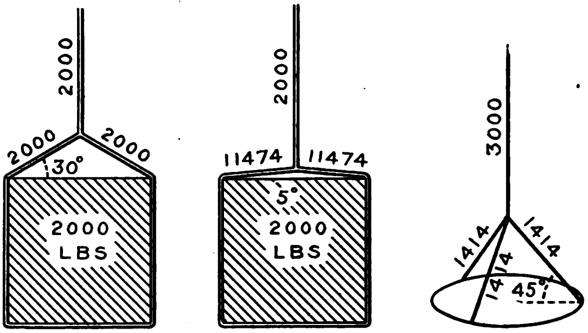


Fig. 4. Fig. 5. Fig 6.

Illustrating the Obliquity of Slings.

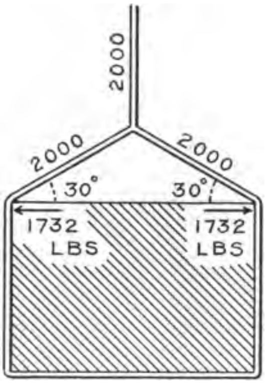


Fig. 7. Illustrating the Pressure of the Sling against the Load

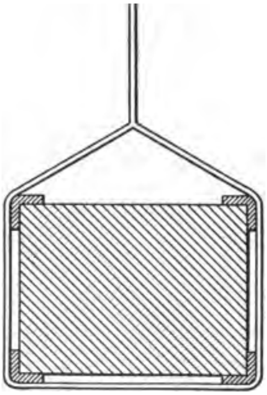


Fig. 8. Illustrating the Use of Wooden Corner-pieces.

PLATE 1.

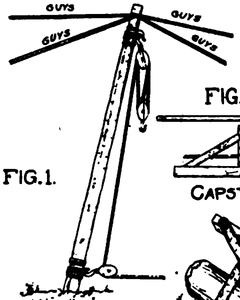


FIG.1.

DERRICK

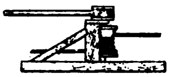


FIG.2.

CAPSTAN

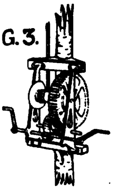


FIG.3.

WINCH.

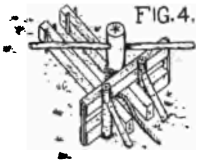


FIG.4.

FIELD CAPSTAN.

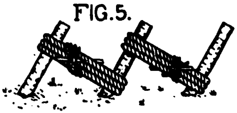


FIG.5.

HOLDFAST.

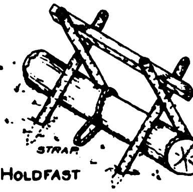


FIG.6.

HOLDFAST

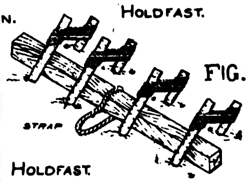


FIG.7.

HOLDFAST.

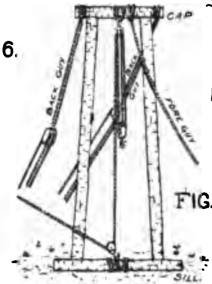


FIG.8.

DERRICK

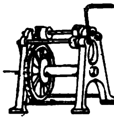


FIG.9.

CRAB.

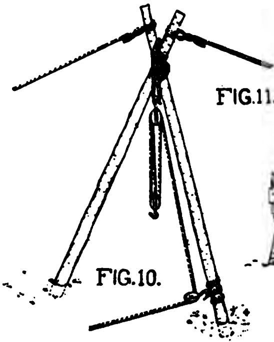


FIG.10.

SHEARS.

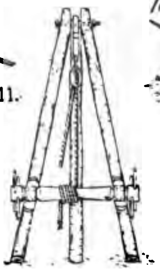


FIG.11.

DERRICK

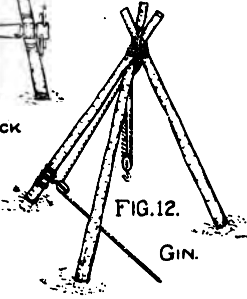


FIG.12.

GIN.

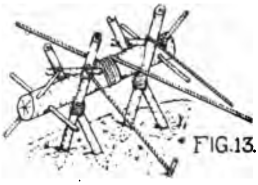
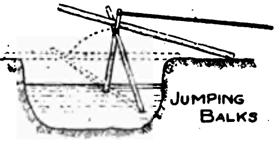


FIG.13.

FIELD WINDLASS.



JUMPING BALKS

FIG.17.

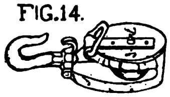


FIG.14.

SNATCH BLOCK

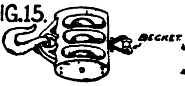


FIG.15.

TREBLE BLOCK

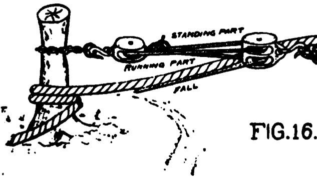


FIG.16.

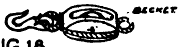


FIG.18.

SINGLE BLOCK.

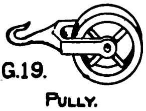


FIG.19.

PULLY.

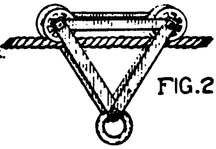


FIG.20.

FERRY BLOCK.

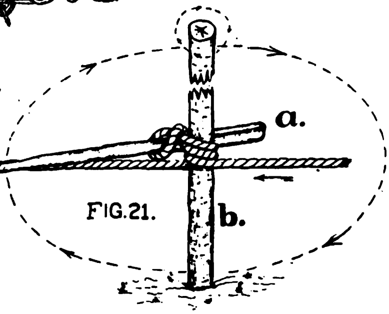


FIG.21.

sd-14

(Plates 1, 2, 3 and 4 Furnished by S. C. Tanner, B. & O. R. R.)

PLATE 2.

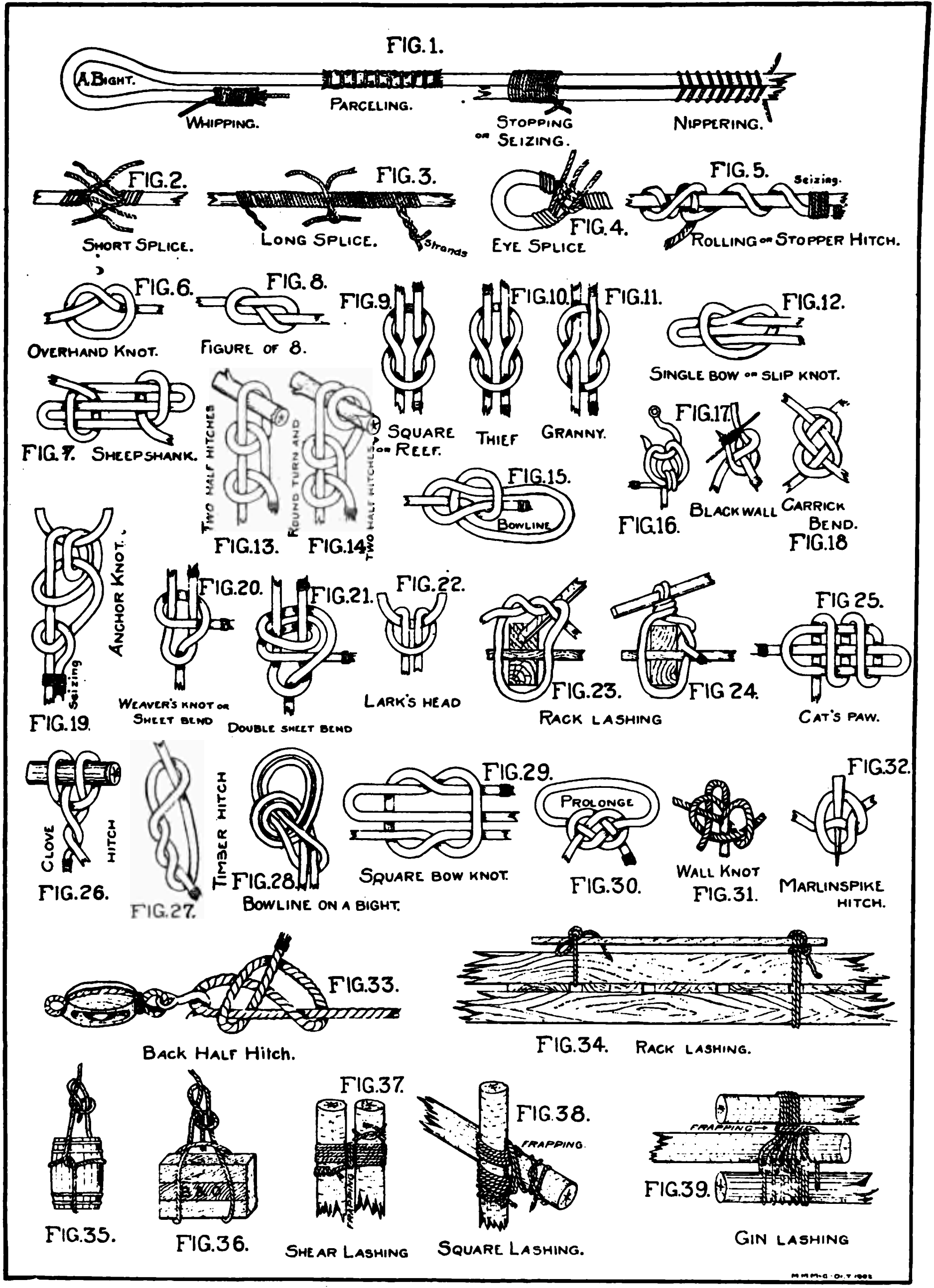


FIG. 1.
A Bight.
Whipping.
Parceling.
Stopping or Seizing.
Nippering.
FIG. 2.
Short Splice.
FIG. 3.
Long Splice.
Strands
FIG. 4.
Eye Splice
FIG. 5.
Seizing.
Rolling or Stopper Hitch.
FIG. 6.
Overhand Knot.
FIG. 8.
Figure of 8.
FIG. 9.
Square or Reef.
FIG. 10.
Thief
FIG. 11.
Granny.
FIG. 12.
Single bow or slip knot.
FIG. 7. Sheepshank.
Two half hitches
FIG. 13.
Round turn and two half hitches
FIG. 14.
FIG. 15.
Bowline
FIG. 16.
FIG. 17.
Blackwall
Carrick Bend.
FIG. 18
Anchor Knot.
Seizing
FIG. 19.
FIG. 20.
Weaver's knot or Sheet bend
FIG. 21.
Double sheet bend
FIG. 22.
Lark's head
FIG. 23.
FIG. 24.
Rack lashing
FIG. 25.
Cat's paw.
Clove hitch
FIG. 26.
FIG. 27.
Timber hitch
FIG. 28.
Bowline on a bight.
FIG. 29.
Square bow knot.
Prolonge
FIG. 30.
Wall Knot
FIG. 31.
FIG. 32.
Marlinspike hitch.
FIG. 33.
Back Half Hitch.
FIG. 34.
Rack lashing.
FIG. 35.
FIG. 36.
FIG. 37.
Frapping
Shear Lashing
FIG. 38.
Frapping.
Square Lashing.
Frapping
FIG. 39.
Gin lashing

5d-14

PLATE 3.

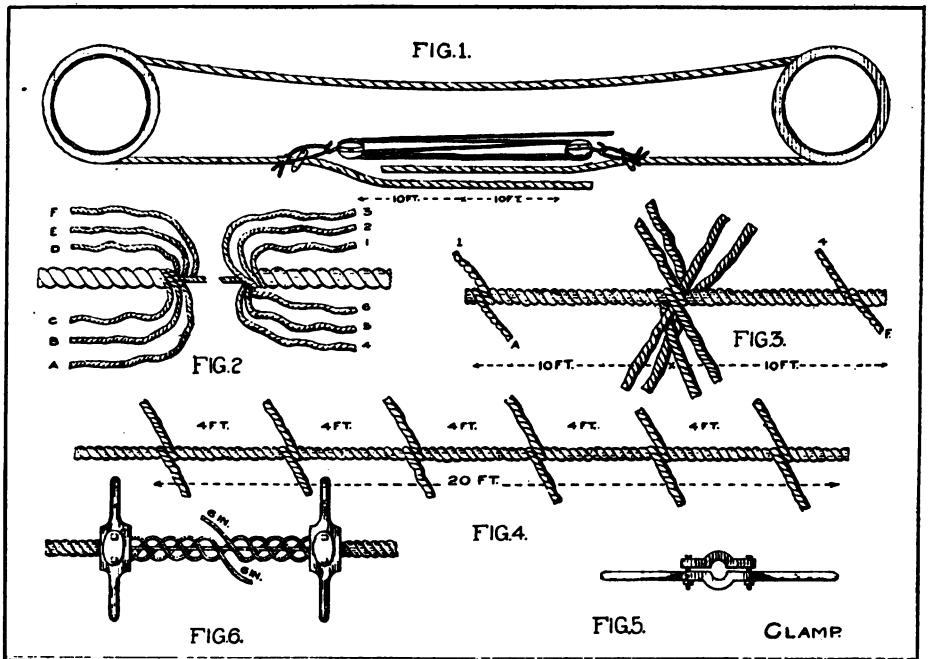


FIG.1.

FIG.2

FIG.3.

FIG.4.

FIG.6.

FIG.5. CLAMP.

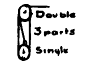
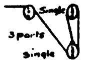
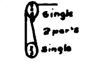
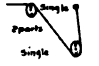
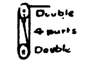
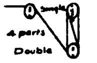
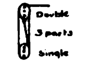
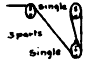
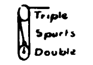
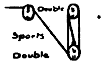
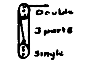
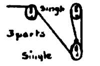
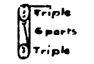
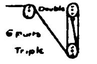
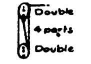
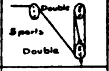
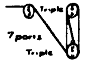
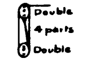
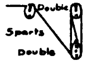
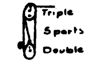
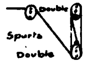
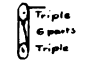
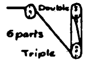
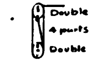
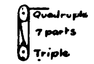
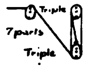
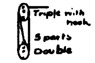
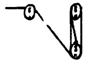
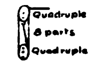
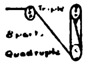
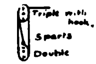
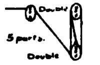
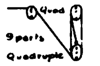
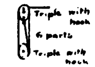
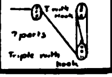
Strength of Manilla Ropes and Lifting Capacity of Tackles.

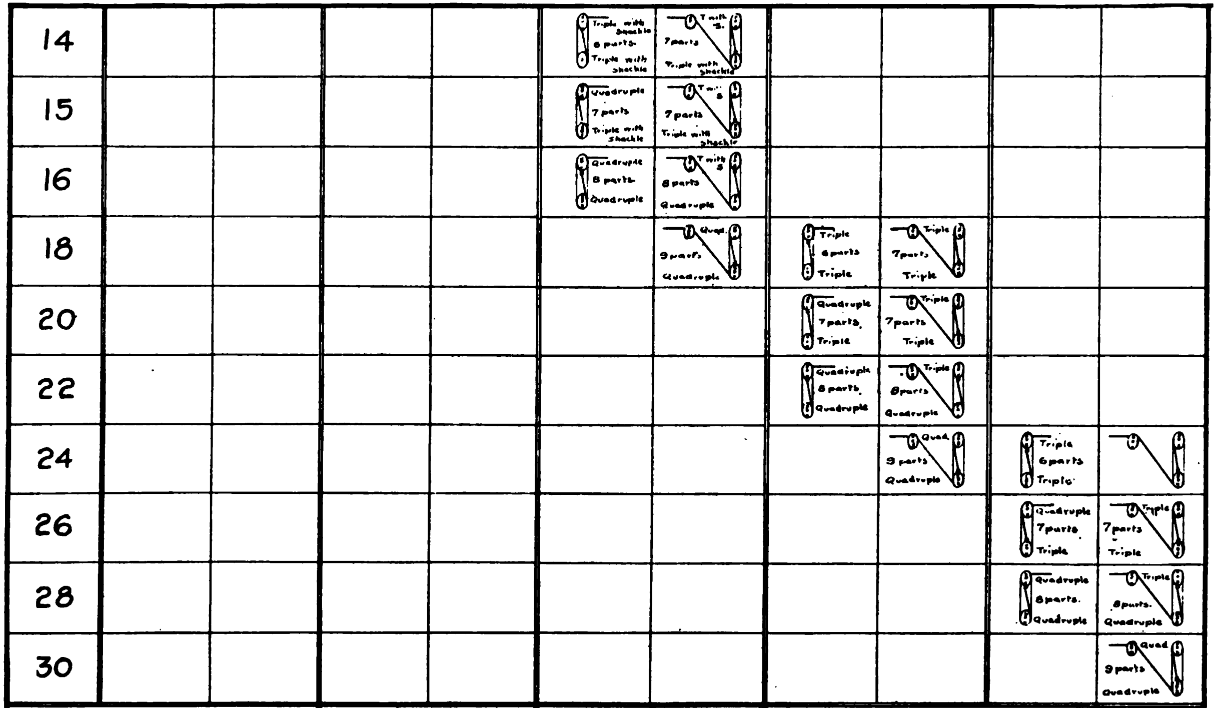
1 Diam. of Rope	2 Circum. of Rope	3 Ultimate Strength	4 Working Strength	Lifting Capacity of Tackles-limiting stress on lead line to values given in Column Nº4. Number of effective parts of line in tackle equals total number of sheaves in tackles.													
				1	2	3	4	5	6	7	8	9	10	11	12	13	14
¾"	2¼"	5700	1900	1590	2960	4160	5090	5890	6610	7180	7750	8200	8550	8780	9120	9360	9560
⅞"	2½"	6900	2300	1930	3590	5040	6160	7130	8000	8690	9380	9940	10350	10630	11040	11360	11590
1"	3"	9300	3100	2600	4840	6790	8310	9610	10790	11720	12650	13390	13950	14320	14880	15310	15680
1¼"	3¾"	12900	4300	3610	6710	9420	11520	13330	14960	16250	17540	18580	19350	19870	20640	21240	21670
1½"	4½"	17700	5900	4950	9200	12920	15810	18290	20530	22300	24070	25490	26550	27260	28320	29150	29730
1¾"	5¼"	23700	7900	6630	12220	17300	21170	24490	27490	29860	32230	34130	35550	36500	37920	39030	39810
2"	6"	30900	10300	8650	16070	22560	27600	31930	35840	38930	42020	44500	46350	47590	49440	50880	51910
2¼"	7"	39300	13100	11000	20430	28890	35100	40610	45590	49520	53450	56590	58950	60520	62880	64710	66020
% of reduction per efficiency				84%	78%	73%	67%	62%	58%	54%	51%	48%	45%	42%	40%	38%	36%

sd-14

PLATE 4.

Lifting Capacity of Tackle

TONS	1¼ IN. LINE		1½ IN. LINE		1¾ IN. LINE		2 IN. LINE		2¼ IN. LINE	
4	 Double 3 parts Single	 Single 3 parts Single	 Single 2 parts Single	 Single 2 parts Single						
5	 Double 4 parts Double	 Single 4 parts Double	 Double 3 parts Single	 Single 3 parts Single						
6	 Triple 5 parts Double	 Double 5 parts Double	 Double 3 parts Single	 Single 3 parts Single						
7	 Triple 6 parts Triple	 Double 6 parts Triple	 Double 4 parts Double	 Double 5 parts Double						
8		 Triple 7 parts Triple	 Double 4 parts Double	 Double 5 parts Double						
9			 Triple 5 parts Double	 Double 5 parts Double						
10			 Triple 6 parts Triple	 Double 6 parts Triple	 Double 4 parts Double					
11			 Quadruple 7 parts Triple	 Triple 7 parts Triple	 Triple with hook 5 parts Double					
12			 Quadruple 8 parts Quadruple	 Triple 8 parts Quadruple	 Triple with hook 5 parts Double	 Double 5 parts Double				
13				 Quad 9 parts Quadruple	 Triple with hook 6 parts Triple with hook	 Triple with hook 7 parts Triple with hook				



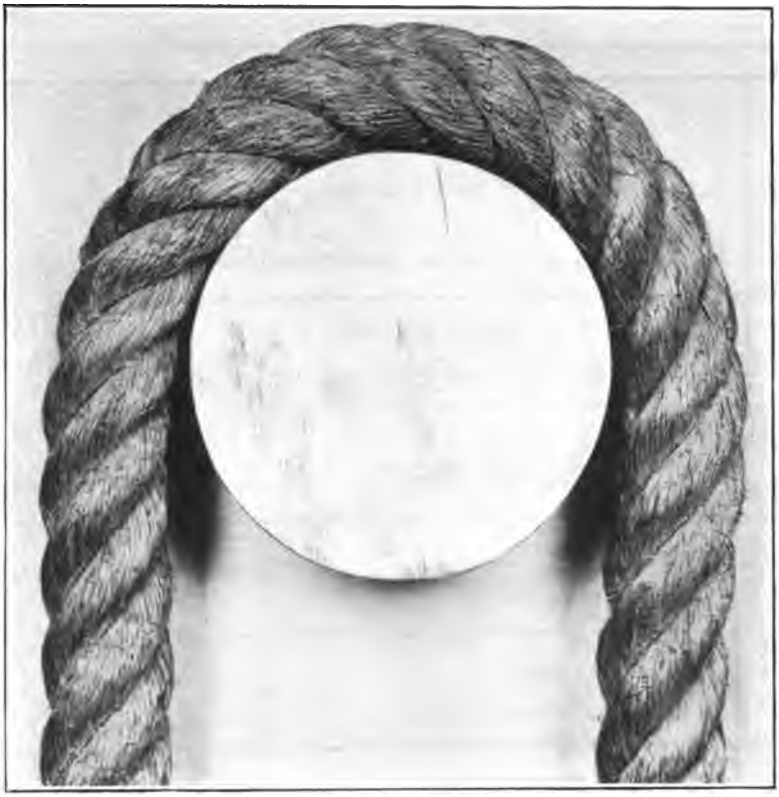
12 in. block for 1¼ in. Line.
Capacity of Blocks.
Single with hook = 5 Tons.
Double " " 7 " "
Triple " " 8 " "
Approx. pull on lead line = 2 Tons.

14 in. block for 1½ in. line.
Capacity of Blocks.
Single with hook = 6 Tons.
Double " " = 10 " "
Triple " " = 12 " "
Quad. with shackle 14 " "
Approx. pull on lead Line = 3 Tons.

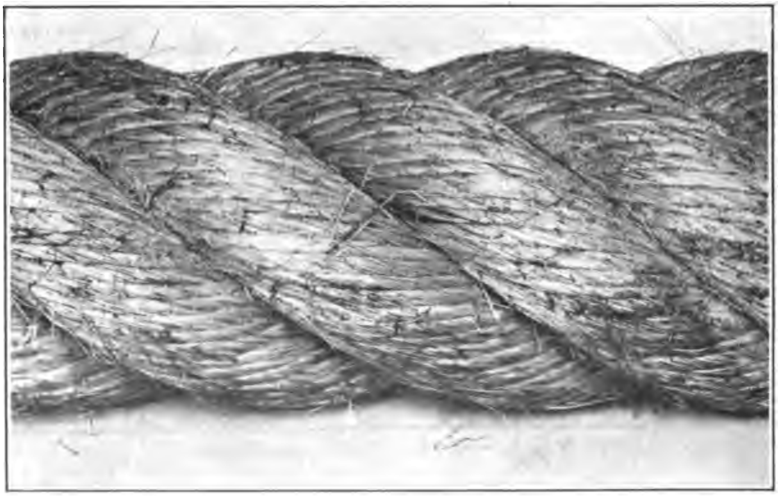
16 in. block for 1¾ in. line.
Capacity of Blocks.
Single with hook = 8 Tons.
Double " " = 12 " "
Triple " " = 13 " "
" " shackle = 18 " "
Quad. " " = 20 " "
Approx. pull on lead Line = 4 Tons.

20 in. blocks for 2 in. and 2¼ in. Line.
Capacity of Blocks
Single with shackle = 15 Tons
Double " " 22 " "
Triple " " 30 " "
Quadruple " " 35 " "
Approx. pull on lead line 5 Tons for 2 in. line.
Approx. pull on lead line 7 Tons for 2¼ in. line.

Sd-14



Action of Rope Fiber Over a Small Sheave.



Two-Inch Manilla Rope.

DISCUSSION.

(Manilla Rope.)

F. E. Weise:—Since this paper was read at the convention Mr. S. C. Tanner has sent in four drawings issued by the Baltimore and Ohio, that add much of interest.

Plates 1 and 2 show knots and splices and the manner of using rope for various purposes. The illustrations are so clear that a detailed description is not needed. There are many cases in which the lack of knowledge of how to tie knots properly and quickly has cost delays and loss of time. A knot must have several requisites in order to be efficient. It must be tied quickly and with a certain degree of assurance and dispatch; there must be no uncertainty as to its holding when pulled tight; and it must be easily opened up. A number of books and articles have been written that go into this subject in detail.

Plate 3 contains a valuable and useful tabulation showing the strength of manilla ropes and the lifting capacity of tackles and the latter subject is further elaborated on Plate 4 by showing in diagrammatic form the arrangement of blocks and lines for various loads and different sizes of ropes. At the bottom of the sheet is also a tabulation showing the capacity of blocks of various sizes.

W. A. Rogers:—Mr. Weise has presented to us, as a society, a very interesting and valuable paper on manilla rope. I confess that while I have paid for a large amount of this important and valuable material, I never have understood its construction as thoroughly as now. Rope is one of those items which is a very necessary part of the outfit of every railroad and every contractor. It is perhaps one of the most abused parts of the outfit which we have, and it is, therefore, a source of leakage. I am sending a copy of Mr. Weise's paper to each of our superintendents, with the hope that the information contained in the article will be of lasting benefit. I wish that Mr. Weise might find time to go into the subject of wire rope as thoroughly as he has into that of manilla rope. With us the use and care of wire rope is of more importance even than manilla rope. We use wire rope in a good many places where formerly manilla rope was used; for instance, for hammer and pile lines on pile drivers. Mr. Weise's paper has covered the subject so fully that it seems impossible to add anything to it.

A. Yappen:—The author gives us all the information relating to where manilla comes from, how it is manufactured into rope, how ropes wear out and what can be done to get the best service. The paper should be furnished to every bridge and carpenter foreman. While the foremen are not interested in the buying of rope, and have to use what is furnished them, they are very much interested in getting good service out of it; and, if a rope is abused it is because they do not know how to care for it; therefore, a paper like this will be of great advantage to them.

There are some things advocated in this paper in the way of caring for rope, that would be hard for our bridge crews to carry out, but it will give them ideas and they may be able to do better than they have in the past. It is not likely that a bridge man will ever apply a sling as shown in the illustrations (which are simply outline sketches), but it will give him an idea as to where the stresses come in a sling, and it may save him trouble at a critical time. It is very necessary for a foreman to understand about splicing, making hitches and knots, and the illustrations in the paper seem to cover everything in that line.

WATER WASTE.

By C. R. Knowles.

As an example of what may be accomplished by a campaign against water waste, the Illinois Central has reduced the expense for city water alone from $225,112 during the fiscal year 1913-14 to $190,438 during the fiscal year 1914-15, a decrease of $34,674. This is a net saving, practically all of which has been accomplished by the elimination of water waste. The expense for city water represents only about 40 per cent of the total cost for water, the remaining 60 per cent being for water pumped by company forces. Consequently there has also been a great reduction in the waste of water pumped by railroad water stations and a resultant saving that can not be shown by figures.

The past few years have seen much activity on the part of water works engineers towards the prevention of water waste. Many of the large cities have organized special departments to conduct water waste surveys and look after water losses. Unfortunately with one or two exceptions this activity has not been felt on railroads, notwithstanding the fact that the railroads are among the largest users of water.

Water is generally considered as free as the air we breathe and much of the waste is due to carelessness on the part of the employés who fail to realize its cost. It follows that careful instruction followed by disciplinary measures, where necessary, is the remedy in a campaign to reduce waste. This lack of coöperation due to ignorance of the value of water, sometimes aided and abetted by departmental lines and jealousies, causes thousands of dollars needless expense to the railroads of the country. American railroads consume approximately 1,950,000,000 gallons of water daily, at an expense of over $100,000. These figures should convince almost anyone that water is not free, and that a saving in water is quite as important as a saving in coal, oil or other supplies. It is safe to say that 15 per cent of all the water used by railroads is waste, meaning by waste, that quantity of water drawn in excess of the amount actually required. An employé who has the interests of the company at heart will not deliberately destroy property or waste supplies, yet that same employé will often leave a valve or faucet open, allowing water to waste, and causing a needless expense that could easily be avoided. The opportunities for water waste on railroads are many and it is within the power of every employé to effect a saving in this respect.

A few illustrations of the most common forms of waste will be given with the cost of such waste and suggested remedies.

Large quantities of water may be wasted in taking water at tanks and penstocks, unless care is exercised to spot the engine properly and to avoid overflowing the tender. Not only does this cause a waste of water but it causes an additional expense for removing ice from the track in winter months and repairs to soft track during the summer. A conservative estimate of the total cost of this waste per annum is $60 per tank. With 30 tanks the annual expense will be $1,800, a sum equal to 5 per cent on $36,000. This will pay the interest and depreciation on the cost of construction of a new 100,000 gal. tank at each station in five years, or will build and maintain a locomotive each year. The remedy is to keep the tank spouts and penstocks in proper repair and to compel the exercise of due care in taking water on locomotives.

One of the most expensive sources of water waste is at engine houses in connection with the use of boiler washout hose and valves. The water used for washing locomotives invariably has to be handled twice to secure the high pressure necessary to wash locomotive boilers properly. The average cost for such water is in excess of ten cents per thousand gallons. A boiler washout hose with a one-inch nozzle will easily waste 12,000 gal. of water per hour at 100 lb. pressure at a cost of $1.20 to $1.50. This does not take into consideration the cost of heating the water where hot water is used for washing. This is a very hard matter to control and results can not be obtained except through the cooperation of the roundhouse force.

Laws prohibiting the use of public drinking cups have made the bubbling drinking fountain a necessity, but the makeshift affairs commonly constructed of ½-in. to 1½-in. pipe and flowing constantly are an abuse to this system of providing drinking water and will waste from $150 to $350 per year for each fountain. The actual amount of drinking water required by a man is about one-half gallon per day. A single bubbling fountain with a ¼-in. opening will deliver 425 gal. per hour at 25 lbs. pressure, which would furnish ample drinking water for 10,000 men and allow 50 per cent waste. The only satisfactory way to control this waste is to restrict the size of the opening and to equip all fixtures of this kind with self closing valves.

Yard hydrants for sprinkling, filling water jugs and coach yard service also cause a heavy waste of water. A one-inch hydrant of this type will waste from 20 to 30 cents' worth of water per hour or $5 to $7 per day. Forty or 50 of these hydrants are often installed in a single coach yard and as a number of them are nearly always open and running the loss is enormous. The improper use of hose for sprinkling, washing coaches, etc., causes a great waste of water that may easily be avoided. To show how water may be wasted in this manner three illustrations are given.

(Illustrations were shown at the convention with the lantern; not shown herewith.)

The first shows a hose with an open end. It is of practically no value for washing or sprinkling as far as efficiency is concerned. The amount of water being wasted and its cost are given in the following table:

One hour	1,080 gal.	at $ .10	$ .108
Ten hours	10,800 "	" .10	1.08
Three hundred hours	324,000 "	" .10	32.40

The second illustration shows the hose without a nozzle but with the stream partially restricted by the pressure of the thumb. This stream is probably about 50 per cent efficient and wastes water as follows:

One hour	540 gal.	at $ .10	$ .054
Ten hours	5,400 "	" .10	.54
Three hundred hours	162,000 "	" .10	16.20

The third photograph shows a hose properly equipped with a nozzle. This stream is doing the maximum amount of work with the minimum waste of water, the water used being as follows:

One hour	180 gal.	at $ .10	$ .018
Ten hours	1,800 "	" .10	.18
Three hundred hours	54,000 "	" .10	5.40

Leaking or improperly adjusted valves in toilet flush tanks will waste from $3 to $50 per month for each battery, depending on the number of fixtures and the cost of water. A case was found recently where toilet facilities at a large terminal were causing a loss of over $400 per month. In another instance the loss was over $150 per month. The trouble was corrected by cutting down the waste of water and the saving at these two points alone amounts to $10,000 per year.

Wash basins, slop sinks and other fixtures connected direct to sewers and drains offer opportunity for heavy water losses and a saving can be made in almost every instance by giving attention to valves and faucets, keeping them in proper repair and making it a point to see that they are closed when not in use.

Another source of waste is through leaks in underground mains. These underground leaks are not always easy to detect. There is nothing in the old saying that "leaks will always show at the surface" for if the pipe is laid in a porous formation or near a sewer the water finds a ready outlet without reaching the surface. The presence of leaks of this kind may sometimes be determined by the use of the aquaphone or sonoscope or by carefully comparing the consumption with the pumpage or meter readings. But locating and repairing the leak is often such a difficult matter that one sometimes wonders whether it is cheaper to permit the pipe to leak or to make repairs. However, this question is easily answered. It always pays to stop leaks. As an illustration of what may be accomplished by stopping underground leaks, the following figures of work done along this line in Washington, D. C., in 1910 are taken from the American Water Works Association proceedings of 1911.

	Number	Waste in gallons per day
Abandoned services and taps leaking	11	305,000
Iron services broken	204	2,438,000
Lead services broken	87	1,202,000
Wiped joints broken	74	710,000
Couplings on services leaking	18	119,000
Curb cocks leaking	30	85,000
Taps blown out	3	50,000
Joints on mains leaking	92	1,034,000
Mains broken	2	332,000
Valves leaking	11	89,000
		6,364,000

This included no leaks or breaks detected by reason of water appearing on the surface of the ground, which goes to prove that watching the surface for underground leakage is a very poor method of locating waste. The great majority of our water mains are underground and their importance is sometimes lost sight of, but if they were brought to the surface the realization of their true condition would doubtless prove an instructive but very unpleasant surprise.

The saving effected in handling cinders with modern cinder pit facilities is often destroyed by the waste of water through hose connections. The photograph shows an actual condition where the waste is 10 gal. per minute, 600 gal. per hour, and 14,400 gal. per day. The cost is $1.44 per day, $10.08 per week or $524.16 per year.

Fire hydrants are often used for drinking and other purposes with a resultant waste of water. The illustration shows a condition by no means uncommon, 100 gal. of water being wasted to secure perhaps a pint. A man will require a drink of water from 4 to 8 times per day of 10 hours or an average of 6 times per day; thus 20 men will drink 120 times a day and by using this method of securing their drinking water will waste 12,000 gal. while drinking 5 gal.

A faucet may be noticed to leak, but no effort is made to close the faucet or repair the leak, for the reason that the possibility for loss is not realized. The first picture shows water leaking drop by drop.

(Illustrations were shown at the convention with the lantern; not shown herewith.)

Wasting Water when Filling a Locomotive Tender.

15	gal. per	day	cost at $	.10	$ .0015
105	“ “	week	“ “	.10	.015
5,475	“ “	year	“ “	.10	.5475

The second picture shows water leaking through a ¼-in. opening:

13,435	gal. per	day	cost at $	.10	$ 1.34
94,045	“ “	week	“ ‘	.10	9.40
4,890,340	“ “	year	“ “	.10	489.03

The third picture shows water leaking through a ½-in. opening:

53,568	gal. per	day	cost at $	.10	$ 5.35
374,976	“ “	week	“ “	.10	37.49
19,498,752	“ “	year	“ “	.10	1,948.75

The rate used in computing the cost of city water is $.10 per thousand gallons, which would probably represent the minimum rather than the average rate as paid for city water. In computing the cost of water in over 300 cities throughout the United States the maximum cost where water was furnished by private companies or a municipal plant, was $0.23 per thousand gallons, while the minimum rate was $.09, making an average rate of $.16 per thousand gallons, the rate in a number of the cities being as high as $.50 per thousand gallons. Thus it will be seen that the saving as given is very conservative.

Wasting Water at Cinder Pit.

Leakage from a Buried Water Main.

DISCUSSION.

(Water Waste.)

The President:—Are there any questions that you would like to ask Mr. Knowles in regard to this subject of water waste? I am sure we have all been very much edified by his paper and will carry home with us a lesson to preach to all our forces.

J. N. Penwell:—I would like to ask Mr. Knowles if the examples shown on the canvas were taken when he caught the fellow unawares?

C. R. Knowles:—With the exception of eight. The three faucets, the three streams from the hose and two of the locomotive tenders overflowing are the only pictures that were posed, the remainder were natural conditions.

J. N. Penwell:—That is an important point to bear in mind, that many of these were cases where he caught the fellow at it; it is a common thing, and I have a picture in my mind where I observed just such a waste of water recently where a washout hose was running wide open with 110 lb. pressure on it.

A. S. Markley:—Isn't it true that a great many of these cases of waste referred to occur in cold weather, when they leave the water running to prevent their hose hydrants, etc., from freezing up, where they are not provided with reels, etc.?

C. R. Knowles:—They are all provided with reels and they should take care of such apparatus. Even if they let the water run, they are going to have a poor condition. If they throw hose on the ground the water is going to freeze on the outside and the hose is going to crack. These are expenses merely incidental to the original waste. There can be but little excuse for allowing waste in order to prevent freezing during the winter months as this may be controlled by installing frost proof valves.

J. S. Robinson of the Northwestern and myself had a conversation two years ago at Montreal, that I think is the beginning of this water waste proposition. I think Mr. Robinson ought to have something to say about water waste. I understand he has been stopping a few leaks on the Northwestern.

J. S. Robinson:—We have adopted a water waste campaign lately; one of our officials appointed a committee, of which I was a member, to examine our water stations of every kind in the city of Chicago, freight yards, coach yards, engine stations, shops, etc. At our shops we consume about 3,000,000 gal. per day, all of which comes from the city of Chicago, for which we pay the regular rate. We have cut down the water consumption a great deal. We have recommended that a very close inspection be kept of the water, whereby we hope we can save about $24,000 a year. I think we paid the city $104,000 for water used at our Chicago shops last year. We hope to cut that down to $80,000. We find at our cinder pits, where we have steam available, that we can jacket the water pipes running along the girders of the cinder pits and by putting a small steam pipe in this jacket it will keep the pipes from freezing. We have also recommended a little self acting valve that can be attached to the end of a hose to prevent waste in our yards, where we wash coaches, etc. Where the hose is likely to freeze we recommend that the entire line be shut off when not in use. An enormous amount of water is wasted if they do not shut off the hose or valves. We have also recommended a jacket for our standpipes, and furnish a little steam coil, especially at the lower end so that the column of water (which now wastes about 100 gal. every time an engine takes water), will not freeze in the standpipe. We have not perfected that yet, but if we can accomplish that at our shops alone, we will save that amount of water every time an engine is filled. Seventy-five engines take water in an hour, thus it will be seen that a great saving can be effected.

C. R. Knowles:—Much of this waste can be prevented without the expenditure of any money other than a small amount for self closing bibbs. It is now the rule on the Illinois Central that we shall use nothing but self closing bibbs where they can be used. Of course, on a connection for a hose we cannot use a self closing valve, but on wash basins, slop sinks and places of that kind we can. The principal thing in a water waste campaign is to get co-operation. Most men laugh at the idea. They think the idea of saving water is a joke. That reminds me of the story a friend of mine told of a lady in Iowa. He said a Jewish lady was charged so much per fixture, 50 cts. for a hydrant, 50 cts. for a bath tub, etc., bills payable quarterly. At the end of the quarter she came around with a bill and complained loudly to the clerk about it, saying, "You charge me for God's own water, which is just as free as the air we breathe; there is $1.50 for that bath tub and we have never used it since we have been there." I don't mean to say that you never use the bath tub, but you overlook the fact that it is working.

I. O. Walker:—We found some of our bills running pretty high and were all anxious to make a record so we began investigation. I found two compressors at work with water from the city mains running through them for cooling and then run to waste. We had a meter put in and found what an enormous amount of water they were using. We had a water tank beside the compressors which we had connected up and saved $80.00 a month by keeping the water and running it back in the tank.

C. R. Knowles:—When you go back home go into your stationary power plants and see whether there is more water being used than is required, and also examine the feed water heater in the stationary boiler plant; the chances are that you will find the overflow leaking. Take your washout system, in fact, any water connection you have with a sewer connection, and you will probably find a waste. Look into the condition of your toilet facilities. They are all wasting water, which means a waste of money. Go into your wash rooms and out of a dozen faucets you will probably find eight of them leaking.

J. S. Robinson:—Can you state what amount you have saved the Illinois Central since you have started this campaign?

C. R. Knowles:—The total reduction for the past fiscal year was $34,903 and the actual net saving on account of the water waste campaign was $33,608.

J. S. Robinson:—What is the amount your company uses in the city of Chicago?

C. R. Knowles:—The cost of city water was $48,120 in 1913-14, and in 1914-15 $40,135.

J. S. Robinson:—Can you give us approximately the number of gallons used per day in the city of Chicago?

C. R. Knowles:—Between 1,800,000 and 2,000,000 gallons.

J. S. Robinson:—We use nearly double that amount.

C. R. Knowles:—We pump a great deal of our own water at 27th street and South Water street. We pump a million gallons per day from the Lake at each of these pumping stations.

L. A. Cowsert:—I would like to speak of the expense of making repairs to the fire plugs because of opening and cracking the valve to get a small stream to drink from; that will allow scale to get under the valve, and closing it down will cut the valve seat. I have had that trouble around shops. It was about a year before I got it stopped and it cost me about $25.00 in three months to keep up those valves besides the water waste. After stopping the drinking from the fire hydrants, we found it cost about $2.00 for three months to keep them up. Another instance of water waste arises when carrying water to cabooses, the men leaving the stream running while making the trip. I called one man's attention to it and asked him how much water he was wasting; he said "about a bucket or two." We found that he was wasting 300 gal. while he was filling a 50 gal. barrel.

W. E. Alexander:—I would infer from what has been said that this water that has been wasted was paid for through meters. We pump the most of our water ourselves, where it is used on the railroad, and for that reason all employes are charged to be conservative with it because it costs the company to pump it. Sometimes there is an overflow at a tank for various causes, and sometimes ice gets under a valve and it does not close well. We have a good deal of ice form in tanks and there is a little waste that way and a fireman is not careful and wastes some water while filling an engine tank, but that is not so common. Where we take water from towns, we take it on a flat rate and the town people help to watch it; hence we don't have such waste. I do not know of any such waste as has been reported here. I do not know of any place where they will open a hydrant to get a drink; we usually provide places for people to drink without opening a hydrant and they do not take that trouble. If we get water on a flat rate, as we do mostly in towns where they supply it, the people furnishing the water watch the waste and if there is any waste they report it and we look after it. I think it is ridiculous to have such waste of water as has been represented here. I think any valve should be re-seated and a new one put on if necessary. Of course we have cold weather and cannot leave the pipes run long on the surface. I know in some places as at ash pits they have a perforated tip and I think they could keep it continually running and it would not freeze up, but that is not economy.

C. R. Knowles:—I would like to suggest to Mr. Alexander to look at his water facilities closely when he goes back home and he will decide that there is room for improvement.

J. S. Robinson:—In the city of Chicago in the last two months, we have had the last flat rate taken off and now take all our water by meter. We find that we can save considerable money. In a shop where we have 3,000 men and have the battery system of fixtures with an automatic flush, we found a tremendous waste. Where the individual flush fixture is used a great deal of water can be saved, as only a few gallons are required for each flush, and then only when used. We tried throttling down the automatic flush to the minimum and still there was a tremendous waste because it runs 24 hours per day, while the individual flush only runs when it is used.

C. R. Knowles:—It is hard to realize that these conditions exist and I am not surprised at the attitude of some of the members, but if you will, out of curiosity, look at your water fixtures when you get back home, you will find that, as the queen of Sheba said to King Solomon, "The half has not been told."

Note: This Association received the title—American Railway Bridge and Building Association—at the 18th annual convention at Washington, D. C., October, 1908. Prior to that time it was called —Association of Railway Superintendents of Bridges and Buildings.

LIST OF ANNUAL CONVENTIONS.

No.	Place.	Date.	Membership.
1	St. Louis, Mo.,	Sept. 25, 1891	60
2	Cincinnati, Ohio,	Oct. 18-19, 1892	112
3	Philadelphia, Pa.,	Oct. 17-19, 1893	128
4	Kansas City, Mo.,	Oct. 16-18, 1894	115
5	New Orleans, La.,	Oct. 15-16, 1895	122
6	Chicago, Ill.,	Oct. 20-22, 1896	140
7	Denver, Colo.,	Oct. 19-21, 1897	127
8	Richmond, Va.,	Oct. 18-19, 1898	148
9	Detroit, Mich.,	Oct. 17-18, 1899	148
10	St. Louis, Mo.,	Oct. 16-18, 1900	143
11	Atlanta, Ga.,	Oct. 15-17, 1901	171
12	Minneapolis, Minn.,	Oct. 21-23, 1902	195
13	Quebec, Canada,	Oct. 20-22, 1903	223
14	Chicago, Ill.,	Oct. 18-20, 1904	293
15	Pittsburg, Pa.,	Oct. 17-19, 1905	313
16	Boston, Mass.,	Oct. 16-18, 1906	340
17	Milwaukee, Wis.,	Oct. 15-17, 1907	341
18	Washington, D. C.,	Oct. 20-22, 1908	368
19	Jacksonville, Fla.,	Oct. 19-21, 1909	393
20	Denver, Colo.,	Oct. 18-20, 1910	428
21	St. Louis, Mo.,	Oct. 17-19, 1911	499
22	Baltimore, Md.,	Oct. 15-17, 1912	524
23	Montreal, Que.,	Oct. 21-23, 1913	570
24	Los Angeles, Cal.,	Oct. 20-22, 1914	586
25	Detroit, Mich.,	Oct. 19-21, 1915	665

	1891-2.	1892-3.	1893-4.	1894-5.
President	O. J. Travis...	H. M. Hall.....	J. E. Wallace....	Geo. W. Andrews.
1st. V.-Pres. .	H. M. Hall.....	J. E. Wallace....	Geo. W. Andrews..	W. A. McGonagle.
2nd. V.-Pres.	J. B. Mitchell..	G. W. Hinman..	W. A. McGonagle.	L. K. Spafford.
3rd. V.-Pres.	James Stannard.	N. W. Thompso	L. K. Spafford....	James Stannard.
4th. V.-Pres. .	G. W. Hinman..	C. E. Fuller....	E. D. Hines......	Walter G. Berg.
Secretary	C. W. Gooch...	S. F. Patterson..	S. F. Patterson....	S. F. Patterson.
Treasurer	George M. Reid.	George M. Reid..	George M. Reid..	George M. Reid.
Executive Members .	W. R. Damon..	G. W. Andrews..	Q. McNab	James Stannard.
	G. W. Markley.	J. M. Staten....	A. S. Markley....	James H. Travis.
	W. A. McGonagle	J. M. Caldwell..	Floyd Ingram.....	J. H. Cummin.
	G. W. McGehee.	Q. McNab.......	James Stannard ..	R. M. Peck.
	G. W. Turner...	Floyd Ingram...	James H. Travis ..	J. L. White.
	J. E. Wallace...	A. S. Markley..	J. H. Cummin	A. Shane.

	1895-6.	1896-7.	1897-8.	1898-9.
President	W. A. McGonagle	James Stannard..	Walter G. Berg....	J. H. Cummin.
1st. V.-Pres. .	L. K. Spafford.	Walter G. Berg..	J. H. Cummin....	A. S. Markley.
2nd. V.-Pres.	James Stannard.	J. H. Cummin...	A. S. Markley....	C. C. Mallard.
3rd. V.-Pres.	Walter G. Berg.	A. S. Markley...	G. W. Hinman....	W. A. Rogers.
4th. V.-Pres. .	J. H. Cummin.	R. M. Peck....	C. C. Mallard.....	J. M. Staten.
Secretary	S. F. Patterson.	S. F. Patterson..	S. F. Patterson....	S. F. Patterson.
Treasurer	George M. Reid.	N. W. Thompso	N. W. Thompson..	N. W. Thompson.
Executive Members .	R. M. Peck....	W. O. Eggleston	G. J. Bishop......	Wm. S. Danes.
	J. L. White...	W. M. Noon....	C. P. Austin......	J. H. Markley.
	A. Shane	J. M. Staten....	M. Riney	W. O. Eggleston.
	A. S. Markley..	G. J. Bishop.....	Wm. S. Danes....	R. L. Heflin.
	W. M. Noon...	C. P. Austin....	J. H. Markley....	F. W. Tanner.
	J. M. Staten...	M. Riney	W. O. Eggleston..	A. Zimmerman.

	1899-1900.	1900-1901.	1901-1902.	1902-1903.
President	Aaron S. Markley	W. A. Rogers....	W. S. Danes.....	B. F. Pickering.
1st. V.-Pres. .	W. A. Rogers...	W. S. Danes.....	B. F. Pickering..	C. C. Mallard.
2nd. V.-Pres.	J. M. Staten....	B. F. Pickering..	A. Shane	A. Shane.
3rd. V.-Pres.	Wm. S. Danes...	A. Shane.......	A. Zimmerman ..	A. Zimmerman.
4th. V.-Pres. .	B. F. Pickering..	A. Zimmerman ..	C. C. Mallard....	A. Montzheimer.
Secretary	S. F. Patterson..	S. F. Patterson..	S. F. Patterson..	S. F. Patterson.
Treasurer	N. W. Thompson	N. W. Thompson.	N. W. Thompson.	N. W. Thompson
Executive Members .	T. M. Strain....	T. M. Strain.....	A. Montzheimer..	W. E. Smith.
	R. L. Heflin....	H. D. Cleaveland.	W. E. Smith.....	A. W. Merrick.
	F. W. Tanner...	F. W. Tanner...	A. W. Merrick...	C. P. Austin.
	A. Zimmerman...	A. Montzheimer.	C. P. Austin.....	C. A. Lichty.
	H. D. Cleaveland	W. E. Smith....	C. A. Lichty.....	W. O. Eggleston.
	A. Montzheimer.	A. W. Merrick...	W. O. Eggleston.	J. H. Markley.

	1903-1904.	1904-1905.	1905-1906.	1906-1907.
President	A. Montzheimer..	C. A. Lichty...	J. B. Sheldon....	J. H. Markley.
1st. V.-Pres. .	A. Shane	J. B. Sheldon..	J. H. Markley....	R. H. Reid.
2nd. V.-Pres.	C. A. Lichty....	J. H. Markley..	R. H. Reid.......	J. P. Canty.
3rd. V.-Pres.	J. B. Sheldon....	R. H. Reid.....	R. C. Sattley....	H. Rettinghouse.
4th. V.-Pres. .	J. H. Markley...	R. C. Sattley...	J. P. Canty......	F. E. Schall.
Secretary	S. F. Patterson..	S. F. Patterson..	S. F. Patterson..	S. F. Patterson.
Treasurer ...	C. P. Austin....	C. P. Austin....	C. P. Austin.....	C. P. Austin.
Executive Members .	R. H. Reid......	W. O. Eggleston	H. Rettinghouse .	W. O. Eggleston
	W. O. Eggleston	A. E. Killam....	A. E. Killam.....	A. E. Killam.
	A. E. Killam....	H. Rettinghouse.	J. S. Lemond.....	J. S. Lemond.
	R. C. Sattley....	J. S. Lemond....	C. W. Richey....	C. W. Richey.
	H. Rettinghouse..	W. H. Finley..	H. H. Eggleston.	H. H. Eggleston
	J. S. Lemond....	C. W. Richey...	F. E. Schall.....	B. J. Sweatt.

	1907-1908.	1908-1909.	1909-1910.	1910-1911.
President	R. H. Reid	J. P. Canty	J. S. Lemond	H. Rettinghouse
1st. V.-Pres.	J. P. Canty	H. Rettinghouse	H. Rettinghouse	F. E. Schall
2nd. V.-Pres.	H. Rettinghouse	F. E. Schall	F. E. Schall	A. E. Killam
3rd. V.-Pres.	F. E. Schall	J. S. Lemond	A. E. Killam	J. N. Penwell
4th. V.-Pres.	W. O. Eggleston	A. E. Killam	J. N. Penwell	L. D. Hadwen
Secretary	S. F. Patterson	S. F. Patterson	C. A. Lichty	C. A. Lichty
Treasurer	C. P. Austin	C. P. Austin	J. P. Canty	J. P. Canty
Executive Members	A. E. Killam	J. N. Penwell	W. Beahan	T. J. Fullem
	J. S Lemond	Willard Beahan	F. B. Scheetz	G. Aldrich
	C. W. Richey	F. B. Scheetz	L. D. Hadwen	P. Swenson
	T. S. Leake	W. H. Finley	T. J. Fullem	G. W. Rear
	W. H. Finley	L. D. Hadwen	G. Aldrich	W. O. Eggleston.
	J. N. Penwell	T. J. Fullem	P. Swenson	W. F. Steffens

	1911-1912.	1912-1913.	1913-1914.	1914-1915.
President	F. E. Schall	A. E. Killam	J. N. Penwell	L. D. Hadwen
1st. V.-Pres.	A. E. Killam	J. N. Penwell	L. D. Hadwen	G. Aldrich
2nd. V.-Pres.	J. N. Penwell	L. D. Hadwen	G. Aldrich	G. W. Rear
3rd. V.-Pres.	L. D. Hadwen	T. J. Fullem	G. W. Rear	C. E. Smith
4th. V.-Pres.	T. J. Fullem	G. Aldrich	C. E. Smith	E. B. Ashby
Secretary	C. A. Lichty	C. A. Lichty	C. A. Lichty	C. A. Lichty
Treasurer	J. P. Canty	J. P. Canty	J. P. Canty	F. E. Weise
Executive Members	G. Aldrich	G. W. Rear	W. F. Steffens	W. F. Steffens
	P. Swenson	W. F. Steffens	E. B. Ashby	S. C. Tanner
	G. W. Rear	E. B. Ashby	S. C. Tanner	Lee Jutton
	W. F. Steffens	C. E. Smith	Lee Jutton	W. F. Strouse
	E. B. Ashby	S. C. Tanner	W. F. Strouse	C. R. Knowles
	W. O. Eggleston	Lee Jutton	C. R. Knowles	A. Ridgway

	1915-1916			
President	G. W. Rear			
1st. V.-Pres.	C. E. Smith			
2nd V.-Pres.	E. B. Ashby			
3rd V.-Pres.	S. C. Tanner			
4th V.-Pres.	Lee Jutton			
Sec.-Treas.	C. A. Lichty			
Executive Members	F. E. Weise			
	W. F. Strouse			
	C. R. Knowles			
	J. S. Robinson			
	J. P. Wood			

CONSTITUTION *

ARTICLE I.

NAME.

SECTION 1. This association shall be known as the American Railway Bridge & Building Association.

ARTICLE II.

OBJECT.

SECTION 1. The object of this association shall be the advancement of knowledge pertaining to the design, construction and maintenance of railway bridges, buildings and other structures, by investigation, reports and discussions, providing a medium for the exchange of ideas to the end that bridge and building practice may be systematized and improved.

SECTION 2. The association shall neither indorse nor recommend any particular devices, trade marks or materials, nor will it be responsible for any opinions expressed in papers, reports or discussions unless the same have received the endorsement of the association in regular session.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The membership of this association shall be divided into two classes—active and life members.

SECTION 2. To be eligible for active membership, a person must be actively employed in railway service in responsible charge of the design, construction or maintenance of railway bridges, buildings or other structures; a professor of engineering in a college or university of recognized standing; an engineering editor, or a government or private timber expert.

SECTION 3. To be eligible for life membership a person must have been a member of the association for at least five years and in general must have retired from active railway service. The association, however, may waive the latter condition by a majority vote of the members at a regular session for good and sufficient reasons. A life member shall have all the privileges of active membership and shall not be required to pay annual dues.

SECTION 4. Any member guilty of conduct unbecoming a railroad officer and a member of this association, or who shall refuse to comply with the rules of this association, may forfeit his membership on a two-thirds vote of the members present at any regular session of the association.

SECTION 5. Membership shall continue until written resignation is received by the secretary, unless member has been previously expelled, or dropped for non-payment of dues in accordance with Section 1 of Article VII.

---

* Revised October, 1914. Amended October, 1915.

ARTICLE IV.

OFFICERS.

Section 1. The officers of this association shall be a president, four vice-presidents, a secretary-treasurer and six executive members, all of whom shall constitute the executive committee.

Section 2. The past presidents of this association who continue to be members shall be entitled to be present at all meetings of the executive committee, of which meetings they shall receive due notice, and be permitted to discuss all questions and to aid said committee by their advice and counsel; but said past presidents shall not have a right to vote, nor shall their presence be requisite in order to constitute a quorum.

Section 3. Vacancies in any office for the unexpired term shall be filled by the executive committee without delay.

ARTICLE V.

EXECUTIVE COMMITTEE.

Section 1. The executive committee shall exercise a general supervision over the financial interests of the association, assess the amount of annual and other dues, call, prepare for and conduct general or special meetings and make all necessary purchases and contracts required to conduct the general business of the association, but shall not have the power to render the association liable for any debt beyond the amount then in the treasury not subject to other prior liabilities. All appropriations for special purposes must be acted upon at a regular meeting of the association.

Section 2. Two-thirds of the members of the executive committee may call special meetings, thirty days' notice being given members by mail.

Section 3. Five members of the executive committee shall constitute a quorum for the transaction of business.

ARTICLE VI.

ELECTION OF OFFICERS AND TENURE OF OFFICE.

Section 1. Except as otherwise provided the officers shall be elected at the regular annual meeting of the association which convenes on the third Tuesday in October, and the election shall not be postponed except by unanimous consent of the members present at said annual meeting. The election shall be by ballot, a majority of the votes cast being required for election. Any active member of the association not in arrears for dues shall be eligible for office, but the president shall not be eligible for reëlection.

Section 2. The president, four vice-presidents and secretary-treasurer shall hold office for one year and the executive members for two years, three being elected each year. All officers will retain their offices until their successors are elected and installed.

Section 3. The term of office of the secretary-treasurer may be terminated at any time by a two-thirds vote of the executive committee. His compensation shall be fixed by a majority vote of the executive committee. The secretary-treasurer shall also serve as secretary of the executive committee.

Section 4. The secretary-treasurer shall be required to give bond in an amount to be fixed by the majority of the executive committee.

ARTICLE VII.

ANNUAL DUES.

Section 1. Every member upon joining the association shall pay to the secretary-treasurer three dollars membership fee and two dollars per year in advance for annual dues. No member one year in arrears for dues shall be entitled to vote at any election, and any member more than one year in arrears shall be stricken from the list of members at the discretion of the executive committee.

ARTICLE VIII.

AMENDMENTS.

Section 1.. This constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that notice of the proposed amendment or amendments has been sent to the members at least sixty days previous to said regular meeting.

BY-LAWS*

TIME OF MEETING.

1. The regular meeting of this association shall convene annually on the third Tuesday in October at 10 a. m.

PLACE OF MEETING.

2. Places of holding the next annual convention may be proposed at any regular session of the association. All the places proposed shall be submitted to a ballot vote of the members present at the annual business session and the place receiving a majority of all votes cast shall be declared the location of the next annual meeting. If no place receives a majority of the votes cast, the place receiving the lowest number of votes shall be dropped on each subsequent ballot until a place is chosen.

3. It shall lie within the power of the executive committee to change the location of the meeting place if it becomes apparent that it is for the best interests of the association.

QUORUM.

4. At the regular meeting of the association, fifteen or more members shall constitute a quorum.

DUTIES OF OFFICERS.

5. The president shall have general supervision over the affairs of the association. He shall preside at all meetings of the association and of the executive committee; shall appoint all committees not otherwise provided for, and shall be ex-officio member of all committees. He shall,

---

* Revised October, 1914. Amended October, 1915.

with the secretary-treasurer, sign all contracts or other written obligations of the association which have been approved by the executive committee. At the annual meetting the president shall present a report containing a statement of the general condition of the association.

6. The vice-presidents in order of seniority shall preside at meetings in the absence of the president and discharge his duties in case of a vacancy in his office.

7. It shall be the duty of the secretary-treasurer to keep a correct record of proceedings of all meetings of this association; to keep correct all accounts between this association and its members; to collect all moneys due the association, and deposit the same in the name of the association. He shall invest all funds not needed for current disbursements as shall be ordered by the executive committee. He shall pay all bills, when properly certified and approved by the president, and make such reports as mav be called for by the executive committee. He shall also perform such other duties as the association may require.

NOMINATING COMMITTEE.

8. After each annual meeting the president shall appoint a committee of five members, not officers of the association, of whom two at least shall be past presidents, and two of whom shall have served on the committee the previous year, which shall prepare a list of names of nominees for officers to be voted on at the next annual convention, in accordance with Article VI of the constitution, said list to be read at the first session of the second day of said convention. Nothing in this section shall be construed to prevent any member making further nominations.

AUDITING COMMITTEE.

9. At the first session of each annual meeting the president shall appoint a committee of three members, not officers of the association, whose duty it shall be to examine the accounts and vouchers of the secretary-treasurer and certify as to the correctness of his accounts. Acceptance of this committee's report will be regarded as the discharge of the committee.

COMMITTEE ON SUBJECTS FOR DISCUSSION.

10. After the annual meeting the president shall appoint a committee whose duty it shall be to prepare a list of subjects for investigation to be submitted for approval at the next convention.

COMMITTEES ON INVESTIGATION.

11. After the association has adopted the list of subjects for investigation the president for the succeeding year shall appoint the committees who shall prepare the subjects for report and discussion. He may also appoint individual members to prepare reports on special subjects, or to report on any special or particular subject.

PUBLICATION COMMITTEE.

12. After each annual meeting the executive committee shall appoint a publication committee consisting of three active members whose duty it shall be to coöperate with the secretary in the issuing of the publications of the association. The assignment of this committee shall be such that at least one member shall have served on the committee during the previous year.

ORDER OF BUSINESS.

13. 1st—Registration of members.
2nd—Reading minutes of the last meeting.
3rd—Admission of new members.
4th—President's address.
5th—Report of secretary-treasurer.
6th—Payment of annual dues.
7th—Appointment of special committees.
8th—Reports of standing committees.
9th—Unfinished business.
10th—New business.
11th—Election of officers and selection of place for holding next annual meeting.
12th—Installation of officers.
13th—Adjournment.

(Report of nominating committee to be read at first session of second day—Section 9 of By-Laws.)

DECISIONS.

14. The votes of a majority of the members present shall decide any question, motion or resolution which shall be brought before the association, unless otherwise provided.

DISCUSSIONS.

15. All discussions shall be governed by Robert's rules of order.

DIRECTORY OF MEMBERS

Aagaard, P., Chief Inspector, I. C. R. R., Chicago.
Airmet, E. S., For. Ptr., O. S. L. R. R., Salt Lake City.
Alexander, W. E., Supt. B. and B., B. & A. R. R., Houlton, Me.
Allard, E. E., For. B. & B., Mo. Pac. Ry., St. Louis.
Anderson, August, Gen'l For. B. and B., L. S. & I. Ry., Marquette, Mich.
L. W. Althof, Asst. Brg. Engr., O. S. L. R. R., Pocatello, Idaho.
Anderson, L. J., For. B. and B., C. & N. W. Ry., Escanaba, Mich.
Andrews, G. W., Asst. to Eng. M. of W., B. & O. R. R., Baltimore, Md.
Andrews, T. O., Gen. For. B. & B., L. E. & W. R. R., Tipton, Ind.
Archbold, H. L., Asst. Engr., Sou. Pac. Co., Los Angeles, Cal.
Arey, R. J., 541 So. Cummings St., Los Angeles, Cal.
Arnold, F. J., Gen. For. B. & B., D. L. & W. R. R., Scranton, Pa.
Ashby, E. B., Chief Engr., L. V. R. R., New York City.
Ashton, D. H.
Astrue, C. J., Asst. Engr., Sou. Pac. Co., San Francisco.
Auge, E. J., Chief Carp., C. M. & St. P. Ry., Wells, Minn.
Austin, C. P., 107 Park St., Medford, Mass.

Bach, C. F., For. B. & B., C. & N. W. Ry., Belle Plaine, Iowa.
Bailey, F. W., Res. Engr., G. H. & H. R. R., Galveston, Texas.
Bailey, S. D., M. C. R. R., Detroit, Mich.
Ball, E. E., Div. Engr., A. T. & S. F. Ry., Fresno, Cal.
Ballenger, D. A., Roadmaster, Southern Ry., Greenville, S. C.
Baluss, F. C., Engr. B. & B., D. M. & N. Ry., Duluth, Minn.
Barber, N. N., Asst. Engr., C. M. & St. P. Ry., Ottumwa, Iowa.
Barnes, O. F., Div. Engr., Erie R. R., Jersey City, N. J.
Barrett, E. K., Supvr. B. and B., F. E. C. Ry., St. Augustine, Fla.
Barrett, J. E., Supt. of Track, B. and B., L. & H. R. Ry., Warwick, N. Y.
Barton, M. M., Master Carp., P. R. R., West Philadelphia, Pa.
Bates, Onward, Civil Engineer, McCormick Bldg., Chicago.
Beahan, Willard, Asst. Engr., N. Y. C. R. R., Cleveland, Ohio.
Beal, F. D., 912 Yeon Bldg., Portland, Ore.
Bean, C. C., Contractor, 243 Benton St., Freeport, Ill.
Beard, A. H., 705 No. 11th St., Reading, Pa.
Beckman, B. F., Engr., F. S. & W. R. R., Fort Smith, Ark.
Beeler, C. L., Asst. Engr., N. Y. N. H. & H. R. R., New Haven, Conn.
Beeson, R. W., Div. For. B. and B., C. & S. Ry., Trinidad, Colo.
Bender, Henry, For. B. & B., C. & N. W. Ry., Eagle Grove, Ia.
Bentele, Hans, Asst. Ch. Engr., Nat. Rys. of Mex., Mexico City, Mex.
Berry, J. S., Supt. B. and B., S. L. S. W. Ry., St. Louis, Mo.
Bibb, J. M., Supvr. B. and B., L. & N. R. R., Birmingham, Ala.
Bigelow, F. M., Supv. B. & B., S. P. L. A. & S. L. R. R., Salt Lake City.
Bishop, McClellan, Mast. Carp., C. R. I. & P. Ry., El Reno, Okla.
Bishop, R. R., For. B. and B., S. P. L. A. & S. L. R. R., Salt Lake City.
Biss, C. H., Engr., New Zealand Govt. Rys., Christchurch, N. Z.
Black, G. W., Div. For. B. & B., Ill. Trac. Sys., Mackinaw, Ill.

Black, J. D., Supvr. B. and B., P. M. R. R., Saginaw, Mich.
Blackwell, J. H., Roadmaster, Sou. Ry., Columbia, S. C.
Blake, L. M., Supv. B. & B., B. & M. R. R., St. Johnsbury, Vt.
Blowers, S. H., For. Carp., B. & O. R. R., Columbus, O.
Bock, J. G., Gen. Br. Insp., C. St. P. M. & O. Ry., St. Paul, Minn.
Bohland, J. A., Br. Engr., G. N. Ry., St. Paul, Minn.
Bonner, J. K., Asst. Supvr. B. & B., N. Y. C. R. R., Rochester, N. Y.
Bouton, W. S., Engr. of Bridges, B. & O. R. R., Baltimore Md.
Bowers, Stanton, Mast. Carp., P. C. C. & St. L. Ry., Bradford, O.
Bowers, S. C., Mast. Carp. of Brdgs., P. C. C. & St. L. Ry., Steubenville, O.
Bowman, R. M., Asst. Engr., L. E. & W. R. R., Indianapolis, Ind.
Boyd, G. E., Div. Engr., D. L. & W. R. R., Buffalo, N. Y.
Boyer, Grant, Div. For. B. & B., M. C. R. R., Detroit, Mich.
Brantner, Z. T., Supt. M. of W. Shops, B. & O. R. R., Martinsburg, W. Va.
Bratten, T. W., Supvr., B. and B., S. P. Co., Oakland Pier, Cal.
Brewer, W. A., Asst. Engr., I. C. C., 914 Karpen Bldg., Chicago.
Bricker, H. R., Inspr. M. of W., B. & O. R. R., Baltimore, Md.
Bridges, T. H., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Briggs, B. A., Supt. Streets, Colorado Springs, Colo.
Brookhart, N. D., Asst. Supv. B. & B., O. S. L. R. R., Pocatello, Idaho.
Brown, Alf., B. & B. Inspr., P. E. Ry., Los Angeles, Cal.
Brown, Thos., Br. Inspr., P. M. R. R., Saginaw, Mich.
Browne, J. B., Gen'l For. B. and B., K. C. C. & S. Ry., Clinton, Mo.
Browne, J. S., Asst. Engr., N. Y. N. H. & H. R. R., New Haven, Conn.
Bruce, R. J., Supvr. B. & B., Mo. Pac. Ry., St. Louis, Mo.
Buck, A. J., Chief Carpenter, C. M. & St. P. Ry., Tacoma, Wash.
Buckley, J. E., Supvr. B. & B., B. & M. R. R., Nashua, N. H.
Bulger, Hugh, For. B. & B., Sou. Pac. Co., Oakland Pier, Cal.
Burgess, W. H., Supvr. B. & B., Sou. Pac. Co., Stockton, Cal.
Burke, Daniel, Supvr. B. and B., Sou. Pac. Co., Tucson, Ariz.
Burckhalter, F. L., Supt. Sou. Pac. Co., Portland, Ore.
Burnett, W. L., For. B. & B., St. L. I. M. & S. Ry., Eudora, Ark.
Burns, W. E., Div. Engr., Corvallis & Eastern R. R., Albany, Ore.
Burpee, Moses, Chief Engr., B. & A. R. R., Houlton, Maine.
Burrell, F. L., Gen'l For. B. and B., C. & N. W. Ry., Fremont, Neb.
Byrd, J. E., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Byrd, L. J., For. B. & B., St. L. I. M. & S. Ry., Dermott, Ark.
Byrd, W. E., Asst. For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.

Cahill, E., Genl. For. B. & B., D. L. & W. R. R., Binghamton, N. Y.
Cahill, M. F., Contractor, 1641 Market St., Jacksonville, Fla.
Cahill, P. W.
Caldwell, J. M., Insp. B. and B., C. I. & L. Ry., Lafayette, Ind.
Caldwell, J. T., For. B. & B., Sou. Pac. Co., Bakersfield, Cal.
Camp, W. M., Editor, Railway Review, Chicago, Ill.
Candee, Eldridge E., Dist. Br. For., N. Y. N. H. & H. R. R., Bridgeport, Conn.
Candee, Elliot E., Dist. Br. For., N. Y. N. H. & H. R. R., Waterbury, Conn.
Canty, J. P., Supvr. B. and B., B. & M. R. R., Fitchburg, Mass.
Cardwell, W. M., Mast. Carp., W. T. Co., Washington, D. C.
Carmichael, Wm., St. J. & G. I. R. R., St. Joseph, Mo.
Carpenter, J. T., 345 No. Bartlett St., Medford, Ore.
Carter, E. M., Supvr. B. and B., T. C. R. R., Nashville, Tenn.
Case, F. M., For. W. S., C. & N. W. Ry., Belle Plaine, Ia.
Casey, W. W., For. B. & B., K. C. S. Ry., Texarkana, Texas.
Catchot, A. J., Supvr. B. & B., L. & N. R. R., Ocean Springs, Miss.
Cayley, W., Supvr., G. T. Ry., Stratford, Ont.
Christy, B. B., Br. For., S. A. L. Ry., Tallahassee, Fla.
Clark, J. H., Asst. Engr., Sou. Pac. Co., Los Angeles, Cal.
Clark, W. A., Chief Engr., D. & I. R. R. R., Duluth, Minn.

Clark, W. M., Mast. Carp., B. & O. R. R., Pittsburgh, Pa.
Clopton, A. S., Supvr. B. & B., M. K. & T. Ry., Oklahoma City, Okla.
Clothier, E. E., Chief Carp., C. M. & St. P. Ry., Mobridge, So. Dak.
Cole, J. E., Gen'l Inspr., Sou. N. E. Ry., Providence, R. I.
Conn, F. J., Supvr. B. & B., C. N. O. & T. P. Ry., Lexington, Ky.
Connolly, C. G., Gen. For. Eng. Dept., D. L. & W., E. Buffalo, N. Y.
Connor, R. E., Supvr. B. & B., Southern Ry., Columbia, S. C.
Cookson, D. M., Asst. Engr., Burma Ry. Extn. Kalaw, Burma, India.
Cooper, H. A., Roadmaster, T. I. Ry., Gananoque, Ont.
Copp, J. P., Mast. Carp., C. R. I. & P. Ry., Haileyville, Okla.
Corbin, W. S., For. B. and B., Sou. Pac. Co., San Pedro, Cal.
Corey, S. T., Ch. Dftsman, Br. Dept., C. R. I. & P. Ry., Chicago.
Cota, G. M., Ch. Clerk, Eng. Dept., C. Vt. Ry., St. Albans, Vt.
Counts, D. E., Supv. B. & B., W. & A. R. R., Dalton, Ga.
Cowsert, L. A., Supv. W. S., C. N. O. & T. P. Ry., Danville, Ky.
Crawford, J. A., B. & B. Master, C. N. Ry., Saskatoon, Sask.
Crites, G. S., Asst. Engr., Sou. Pac. Co., Tucson, Ariz.
Crosman, D. M., Asst. Engr., Sou. Pac. Co., Los Angeles, Cal.
Cullen, F. P., For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Cullen, J. F., For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Cummin, Joseph H., Bay Shore, N. Y.
Cunningham, A. O., Chief Engr., Wabash R. R., St. Louis, Mo.
Curtin, William, Contractor, Govan, Saskatchewan.

Dale, Wm. C., For. W. S., O. S. L. R. R., Pocatello, Idaho.
Dalstrom, O. F., Ch. Dftsman, Br. Dept., C. & N. W. Ry., Chicago.
Danes, E. C., Gen. For., Wabash R. R., Peru, Ind.
Danes, W. S., Engr. M. of W., Wabash R. R., Peru, Ind.
Dawley, W. S., 5657 Cabanne Ave., St. Louis, Mo.
Decker, H. H., Contractor, 1707 Pleasant St., Des Moines, Ia.
Degnan, L. V., 1834 Hearst Ave., Berkeley, Cal.
Demars, E. A., For. W. S., O. S. L. R. R., Salt Lake City.
Derr, W. L., Supt., C. G. W. R. R., Clarion, Iowa.
Develin, R. G., Asst. Engr. M. of W., P. R. R., Philadelphia, Pa.
DeWitt, H. R., Asst. Engr., Mo. Pac. Ry., Little Rock, Ark.
Dickson, Geo., For. Brdgs., Sou. Pac. Co., Oakland, Cal.
Dittmar, F. C., Br. For., Sou. Pac. Co., Los Angeles, Cal.
Dodd, A. M.,
Donaldson, C. E., Actg. G. F. B. & B., C. Vt. R. R., St. Albans, Vt.
Drake, R. M., M. of W. Asst., Sou. Pac. Co., San Francisco, Cal.
Draper, F. O., Supt. of Bridges, I. C. R. R., Chicago.
Draper, I. A., Steel Erec. For., O. S. L. R. R., Pocatello, Idaho.
Drum, H. R., Chief Carp., C. M. & St. P. Ry., Mitchell, S. D.
Duckett, W. E., Asst. Engr., C. M. & St. P. Ry., Minneapolis, Minn.
Dufort, S. E., Gen. For. B. & B., B. & M. R. R., Lowell, Mass.
Dupree, James, For. W. S., C. T. H. & S. E. Ry., Crete, Ill.
Durfee, T. H., For. B. and B., C. & N. W. Ry., Huron, S. D.

Eastman, J. S., Idaho Falls, Idaho.
Easton, G. A., Scale Insp., Sou. Pac. Co., West Oakland, Cal.
Edwards, W. R., Sr. Struct. Engr., I. C. C., Washington, D. C.
Eggers, C. H., Mast. Carp., C. R. I. & P. Ry., Little Rock, Ark.
Eggleston, H. H., Supvr. B. & B., C. G. W. R. R., Des Moines, Ia.
Eggleston, W. O., Insp. of Bridges, Erie R. R., Huntington, Ind.
Elder, W. E., Mast. Carp., C. B. & Q. R. R., Burlington, Iowa.
Elliott, R. O., Supvr. B. and B., L. & N. R. R., Nashville, Tenn.
Elwell, H. A., Supvr. B. & B., C. G. W. Ry., Clarion, Ia.
Esping, Chas., Mast. Carp., B. & O. C. T. R. R., Chicago.
Ettinger, C., Gen. Ptr. For., I. C. R. R., Chicago.
Evans, J. J., Supvr. Signals, P. M. R. R., Saginaw, Mich.

Fair, E. W., Supvr. B. & B., B. R. & P. Ry., Du Bois, Pa.
Fake, C. H., Engr. M. of W., M. R. & B. T. Ry., Bonne Terre, Mo.
Fellows, C. W., For. W. S., C. & S. Ry., Denver, Colo.
Fenwick, G. H., Gen. Br. For., M. C. R. R., St. Thomas, Ont.
Ferdina, A. H., For. B. & B., St. L. I. M. & S. Ry., St. Louis.
Ferris, B. F., For. B. and B., Sou. Pac. Co., Los Angeles.
Findley, A., 929 Wash. Ave., Portland, Me.
Finley, W. H., Ch. Engr., C. & N. W. Ry., Chicago.
Fisher, J. F., Bridge Inspr., Sou. Pac. Co., Sacramento, Cal.
Fisher, Morris, Supvr. B. & B., Sou. Pac. Co., Ogden, Utah.
Fisk, C. H., Cons. Engr., 1232 Oakley Place, St. Louis, Mo.
Fitzgerald, J. M., Supvr. B. & B., C. of G. Ry., Macon, Ga.
Fletcher, J. W., Val. Engr., Car. & N. W. Ry., Chester, S. C.
Flint, C. F., For. B and B., C. V. R. R., St. Albans, Vt.
Floren, E. R., Mast. Carp., C. R. I. & P. Ry., Rock Island, Ill.
Flynn, M. J., For. B. and B., C. & N. W. Ry., Chicago.
Forsgren, Oscar, Brigham, Utah.
Fowlkes, J. R., Roadmaster, Southern Ry., Columbia, S. C.
Fraser, Alex., Supvr. B. & B., Sou. Pac. Co., Bakersfield, Cal.
Fraser, James, Ch. Engr., N. S. W. Govt. Rys., Sydney, N. S. W.
Fraser, Neil, Gen'l Br. For., Sou. Pac. Co., Mayfield, Cal.
Frazier, W. C., Supvr. B. and B., S. P. L. A. & S. L. Ry., Los Angeles.
Fritz, Phil., For. B. & B., Sou. Pac. Co., Los Angeles.
Froese, Julius, Gen. For. B. & B., A. T. & S. F. Ry., LaJunta, Colo.

Gable, Franklin, For. Carp., P. & R. Ry., Catawissa, Pa.
Gaby, F. A., Ch. Engr. P. C. of Ont., Toronto, Ont.
Gagnon, Ed., Supvr. B. and B., M. & St. L. R. R., Minneapolis, Minn.
Galloway, W. J., Mast. Carp., S. A. L. R. R., Hamlet, N. C.
Gardner, E. F., Mast. Carp., Erie R. R., Buffalo, N. Y.
Garner, R. D., Engr. Const., S. N. E. Ry., Providence, R. I.
Gaskin, W., Scale Inspr., Sou. Pac. Co., Los Angeles, Cal.
Gaunt, Fred, Ptr. For., O. S. L. R. R., Pocatello, Idaho.
Gaut, J. B., Supt. B. & B., G. T. Ry., Chicago.
Gauthier, A. I., Supvr. B. & B., B. & M. R. R., Concord, N. H.
Gehr, B. F., Mast. Carp., P. C. C. & St. L. Ry., Richmond, Ind.
Gentis, Ira, B. and B. Foreman, Sou. Pac. Co., Oakland, Cal.
George, E. C., Supvr. B. and B., G. C. & S. F. Ry., Beaumont, Tex.
George, W. J., Bay Road, Claremont, W. Australia.
Gilman, A. F., Asst. Engr., C. St. P. M. & O. Ry., St. Paul, Minn.
Giusto, Peter, For. B. & B., Sou. Pac. Co., San Francisco.
Given, J. A., Asst. Div. Engr., Sou. Pac. Co., Sacramento. Cal
Glasgow, J. F., Gen. For. B. & B., C. St. P. M. & O. Ry., Worthington, Minn.
Gnadt, C., Br. For., St. L. I. M. & S. Ry., Poplar Bluff, Mo.
Gokey, J. C., For. Water Service, G. T. Ry., Richmond, Que.
Goldmark, Henry, Cons. Engr., 103 Park Ave., New York City.
Gooch, C. W., 1325 W. 9th St., Des Moines, Ia.
Gordon, Guy, For. Water Service, C. R. I. & P. Ry., Little Rock, Ark.
Gradt, Chas. Ch. Carp., C. M. & St. P. Ry., Savanna, Ill.
Graham, F. N., Asst. Engr., C. & N. W. Ry., Boone, Iowa.
Graham, Wm., C. E., 3027 Windsor Ave., Baltimore, Md.
Gratto, James, Supvr. B. & B., S. P. Co., Los Angeles, Cal.
Graves, Lon, For. B. & B., St. L. I. M. & S. Ry., Dermott, Ark.
Green, C. F., Supvr. B. and B., Sou. Pac. Co., Sacramento, Cal.
Green, E. H. R., Pres., Texas Midland R. R., Terrell, Tex.
Greiner, J. E., Civil Engineer, 605 Continental Bldg., Baltimore, Md.
Griffith, F. M., Supvr. B. and B., C. & O. Ry., Covington, Ky.
Grover, J. H., Gen. For. W. S., A. T. & S. F. Ry., Needles, Cal.
Grover, O. L., Asst. Engr., C. & O. Ry., Richmond, Va.

Guild, Edward, Supv. B. & B., P. M. R. R., Grand Ledge, Mich.
Guire, W. A., For. B. & B., St. L. I. M. & S. Ry., Lake Providence, La.
Guppy, B. W., Engr. Structures, B. & M. R. R., Boston, Mass.
Guretzky, J., For. B. and B., Col. Mid. Ry., Colorado City, Colo.

Hadwen, L. D., Engr. Masy. Const., C. M. & St. P. Ry., Chicago, Ill.
Haley, W. S., Res. Engr., N. Y. C. R. R., Toledo, O.
Hall, N. L., Supvr. B. & B., Sou. Ry., Greensboro, N. C.
Hall, Thomas, Asst. Supt. Bldgs., M. C. R. R., Jackson, Mich.
Hampton, H. A., Asst. Div. Engr., Sou. Pac. Co., Portland, Oregon.
Hand, Geo. W., Valuation Engr., C. & N. W. Ry., Chicago.
Hanks, G. E., Saginaw, Mich.
Hansen, Robt., Carp. For., Sou. Pac. Co., West Oakland, Cal.
Hansen, Rupert, For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Hargrove, J. C., For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Harlow, A. W., Mast. Carp., Erie R. R., Huntington, Ind.
Harman, H. H., Engr. of Brs., B. & L. E. R. R., Greenville, Pa.
Harman, Wm. C., Br. Inspr., Sou. Pac. Co., Bakersfield, Cal.
Harris, C. J., For. B. and B., O. S. L. R. R., Roberts, Idaho.
Harris, W. B., Valuation Engr., M. & O. R. R., Jackson, Tenn.
Harshbarger, C. A., Asst. Br. For., O. S. L. Ry., Ontario, Ore.
Hartley, James, Supvr. B. and B., N. P. Ry., Staples, Minn.
Harvey, E. H., St. L. I. M. & S. Ry., Montrose, Ark.
Hausgen, W., Supvr. B. and B., M. P. Ry., Sedalia, Mo.
Hawkins, E. P., Genl. R. M., St. L. I. M. & S. Ry., McGehee, Ark.
Henderson, J., Foreman B. and B., G. T. Ry., St. Thomas, Ont.
Henderson, R. C., For. W. S., B. & O. R. R., Garrett, Ind.
Herrig, C., For. W. S., C. & N. W. Ry., Wall Lake, Iowa.
Higgins, H. K., Cons. Engr., 209 McBride St., Jackson, Mich.
Hill, H. R., Asst. Supvr. B. & B., L. & N. R. R., Birmingham, Ala.
Hinchee, J. M., For. B. & B., Sou. Pac. Co., Los Angeles, Cal.
Hitesman, U. S., Gen. For., N. Y. C. R. R., New York City.
Hodges, F. J., C. C., M. C. R. R., Jackson, Mich.
Hofecker, Peter, Supvr. B. and B., L. V. R. R., Auburn, N. Y.
Holcomb, J. W., Supvr. B. & B., L. V. R. R., Buffalo, N. Y.
Holdridge, H. D., Supvr. B. and B., Y. & M. V. R. R., Vicksburg, Miss.
Hopke, W. T., Mast. Carp., B. & O. R. R., Grafton, W. Va.
Horning, H. A., Supt. of Bldgs., M. C. R. R., Jackson, Mich.
Horth, A. J., Mast. Carp., Erie R. R., Meadville, Pa.
Howson, E. T., Eng. Editor, Railway Age Gazette, Chicago, Ill.
Hubbard, A. B., 32 Banks St., West Somerville, Mass.
Hudson, B. M., Gen. For. B. & B., T. & B. V. Ry., Teague, Tex.
Hull, K. S., Supt., G. C. & S. F. Ry., Temple, Tex.
Humbert, A. T., Mast. Carp., B. & O. R. R., New Castle Jct., Pa.
Hume, E. S., Deputy Com'r., W. A. Govt. Rys., Perth, W. Australia.
Hunciker, John, For. Bridge Erection, C. & N. W. Ry., Chicago.
Huntoon, J. S., Ch. Br. Insp., M. C. R. R., Detroit, Mich.
Hurst, Walter, Inspector, C. B. & Q. Ry., Chicago, Ill.
Hutchens, J. A., Bridge Insp., Sou. Pac. Co., Ogden, Utah.

Ingalls, F., Supvr. B. and B., N. P. Ry., Jamestown, N. D.
Ingram, Floyd, Supvr. B. and B., L. & N. R. R., Erin, Tenn.
Innes, J., Gen. For., G. T. Ry., Hamilton, Ont.
Irwin, J. W., Genl. For. B. & B., C. & N. W. Ry., Chadron, Neb.
Isaacs, Jno. D., Consulting Engr., Sou. Pac. Co., New York City.

Jack, H. M., Gen'l For. B. and B., I. & G. N. R. R., Palestine, Tex.
James, A. J., Gen. For. B. & B., A. T. & S. F. Ry., Topeka, Kans.
James, Harry, Gen'l For. B. and B., C. & S. Ry., Denver, Col.

James, R. E., Supv. B. & B., L. V. R. R., Hazelton, Pa.
Jardine, Hugh, Asst. Engr., Intercolonial Ry., Moncton, N. B.
Jennings, Geo. H., Asst. Ch. Engr., E. J. & E. Ry., Joliet, Ill.
Jensen, C. A., For. B. & B., Sou. Pac. Co., Los Angeles, Cal.
Jewell, J. O., Supt. B. and B., C. T. H. & S. E. Ry., Terre Haute, Ind.
Johnson, C. H., For. B. & B., P. M. R. R., Saginaw, Mich.
Johnson, Maro, Engr. B. & B., I. C. R. R., Chicago.
Johnson, Phelps, Pres. St. Lawrence Bridge Co., Montreal, Que.
Johnston, C. E., Ch. Engr., K. C. Sou. Ry., Kansas City, Mo.
Johnston, J. H., Supt. B. & B., G. T. Ry., Montreal, Que.
Jonah, F. G., Chief Engr., St. L. & S. F. R. R., St. Louis, Mo.
Joslin, Judson, Genl. For. B. & B., L. V. R. R., Auburn, N. Y.
Jutton, Lee, Div. Engr., C. & N. W. Ry., Madison, Wis.

Keefe, D. A., Consulting Engr., Athens, Pa.
Keith, H. C., Civil Engineer, 116 Nassau St., New York City.
Kelly, C. W., Peoples Gas Building, Chicago.
Kelly, J. A., Gen. For. Brs., O. S. L. R. R., Pocatello, Idaho.
Kemp, A. E., For. B. & B., L. V. R. R., Hazleton, Pa.
Kibbey, G. S., Asst. Engr., M. & St. L. R. R., Minneapolis, Minn.
Killam, A. E., 84 Highfield St., Moncton, N. B.
Killian, J. A., Res. Engr., Sou. Ry., Charlotte, N. C.
King, A. H., Supvr. B. and B., O. S. L. R. R., Pocatello, Idaho.
King. C. F., Div. Engr., C. & N. W. Ry., Omaha, Neb.
King, F. E., Dist. Carp., C. M. & St. P. Ry., Minneapolis, Minn.
Kinney, G. W., Inspr. B. & B., D. & R. G. R. R., Salt Lake City.
Kinzie, H. H., Supvr. B. and B., N. Y. N. H. & H. R. R., Taunton, Mass.
Klumpp, G. J., Supvr. Bridges, N. Y. C. R. R., Rochester, N. Y.
Knapp, F. A., Mast. Carp., Erie R. R., Jersey City, N. J.
Knowles, C. R., Gen. For. Water Works, I. C. R. R., Chicago.
Krausch, W. T., Engr. Bldgs., C. B. & Q. R. R., Chicago, Ill.
Krutsinger, M. R., Supvr. B. & B., W. Pac. Ry., Sacramento, Cal.
Kulp, B. R., Div. Engr., C. & N. W. Ry., Antigo, Wis.

Lacy, J. D., Insp., S. A. & A. P. Ry., 2517 Saltus St., Houston, Tex.
Lacy, W. J., For. B. & B., St. L. I. M. & S. Ry., Poplar Bluff, Mo.
La Fountain, N. H., Asst. Supt. of B. and B., C. M. & St. P. Ry., Chicago.
Lamb, C. W., For. B. & B., St. L. I. M. & S. Ry., Pine Bluff, Ark.
Land, G. W., Supvr. B. and B., St. L. I. M. & S. Ry., McGehee, Ark.
Lane, E. G., Dist. Engr. M. of W., B. & O. R. R., Cincinnati, O.
Lanning, W. R., Ch. Carp., C. M. & St. P. Ry., St. Maries, Idaho.
Large, H. M., Mast. Carp., G. R. & I. Ry., Fort Wayne, Ind.
Larsen, A., Res. Engr., S. N. E. R. R., Millville, Mass.
Larson, John, Room 740, Transportation Bldg., Chicago.
Lawrence, P. P., Asst. Supvr. B. & B., L. E. & W. R. R., Tipton, Ind.
Layfield, E. N., 1735 Monadnock Block, Chicago.
Leake, T. S., Contractor, 6433 Kenmore Ave., Chicago.
Leavitt, F. J., Div. For. B. and B., B. & M. R. R., Sanbornville, N. H.
Lee, Frank, Prin. Asst. Engr., C. P. R., Winnipeg, Manitoba.
Lemond, J. S., Engr., M. of W., Southern Ry., Charlotte, N. C.
Lentz, C. W., Supv. B. & B., I. C. R. R., Dubuque, Iowa.
Leonard, H. R., Engr. B. and B., P. R. R., Philadelphia, Pa.
Leslie, Andrew, Div. For., M. C. R. R., St. Thomas, Ont.
Lewis, E. R., Asst. to G. M., D. S. S. & A. Ry., Duluth, Minn.
Lichty, C. A., Gen'l Insp., C. & N. W. Ry., Chicago.
Little, J. W., Asst. Supvr., B. & B., L. & N. R. R., Birmingham, Ala.
Lloyd, F. F., C. E., 1365 Taylor St., San Francisco, Cal.
Lodge, Harry, For. B. & B., Sou. Pac. Co., Tracy, Cal.
Loeffler, M., Supv. Brs., L. I. R. R., Jamaica, N. Y.
Loftin, E. L., Supvr. B. and B., Q. & C. Ry., Vicksburg, Miss.

Long, M. A., Asst. to Ch. Engr., B. & O. R. R., Baltimore, Md.
Lorch, J. A., Asst. Engr., C. & N. W. Ry., Chicago.
Lutken, P. K., Gen. For. B. & B., N. O. M. & C. R. R., Laurel, Miss.
Loughery, E., Gen'l For. B. & B., T. & P. Ry., Dallas, Tex.
Loughnane, George, Div. Engr., C. & N. W. Ry., Escanaba, Mich.
Loweth, C. F., Ch. Engr., C. M. & St. P. Ry., Chicago.
Lydston, W. A., 105 Norfolk Ave., Swampscott, Mass.
Lyman, C. R., For. Brgs., C. Vt. Ry., Waterbury, Vt.

Mace, B. S., Supt. of Insurance, B. & O. R. R., Baltimore, Md.
Mackenzie, W. B., Civil Engineer, Moncton, N. B.
Macy, E. C., Supt. Const., Stone & Webster Eng. Corpn., 868 Stuart Bldg., Seattle, Wash.
Mahan, Wm., Mast. Carp., W. & L. E. R. R., Canton, Ohio.
Malloy, J. B., For. B. & B., Sou. Pac. Co., San Francisco.
Mann, J. M., Gen'l For. B. and B., Ft. W. & D. C. Ry., Ft. Worth, Tex.
Manning, M. G., Supvr. W. S., C. G. W. R. R., Ft. Dodge, Iowa.
Manthey, G. A., Asst. Supt. B. & B., Soo Line, Minneapolis, Minn.
Marcy, C. A., For. B. and B., C. & N. W. Ry., Chicago.
Markley, A. S., Mast. Carp., C. & E. I. R. R., Danville, Ill.
Markley, J. H., Mast. B. and B., T. P. & W. Ry., Peoria, Ill.
Marsh, John, For. B. and B., B. & M. R. R., Lawrence, Mass.
Maruyama, Y., C. E., Sou. Manchuria Ry., Dairen, Japan.
Massenburg, W. G., Div. Engr., G. C. & S. F. Ry., Beaumont, Tex.
Mathews, J. D., Div. Engr., Sou. Pac. Co., Tucson, Ariz.
Matthews, W. H., Mast. Carp., Erie R. R., Hornell, N. Y.
Mattos, F. D., Supt. Pres. Wks., S. P. Co., W. Oakland, Cal.
May, A. D., Asst. Engr., Mo. Pac. Ry., Little Rock, Ark.
Mayer, M. J., Ch. Draftsman, Sou. Pac. Co., San Francisco, Cal.
McCabe, E. M., Supv. B. & B., B. & A. R. R., Pittsfield, Mass.
McCandless, C. W., For. B. & B., Sou. Pac. Co., Ventura, Cal.
McCann, E., Gen. For. B. and B., A. T. & S. F. Ry., Wellington, Kans.
McCaulley, S. W., C. E., 6106 Kenwood Ave., Chicago, Ill.
McCloy, A. L., For. B. & B., P. M. R. R., Reese, Mich.
McCormick, R. S., Ch. Engr., A. C. & H. B. R., Sault Ste. Marie, Ont.
McCoy, W. H., Asst. Engr., Sou. Pac. Co., Dunsmuir, Cal.
McCue, G. C., Gen. Supvr. B. & B., G. T. Ry., Ottawa, Ont.
McCully, C. S., Gen'l For. B. and B., N. P. Ry., Jamestown, N. D.
McDonald, Hunter, Ch. Engr., N. C. & St. L. Ry., Nashville, Tenn.
McFadden, T. E., Chief Carp., C. M. & St. P. Ry., Cedar Falls, Wash.
McGee, Danl., For. B. & B., Sou. Pac. Co., Sacramento, Cal.
McGonagle, W. A., Pres., D. M. & N. Ry., Duluth, Minn.
McIntosh, Wm., Jr., Tarradale Hotel, Muir of Ord., Rosshire, Scotland.
McIver, B. T., Supvr. B. and B., D. & I. R. R. R., Two Harbors, Minn.
McKay, A. G., Div. For. Bldgs., N. Y. N. H. & H. R. R., New Haven, Conn.
McKee, D. L., For. B. and B., P. & L. E. R. R., McKee's Rocks, Pa.
McKee, H. C., Insp. of Iron Bridges, C. of G. R. R., Macon, Ga.
McKee, R. J., Supvr. B. and B., I. C. R. R., Freeport, Ill.
McKeel, W. S., Mast. Carp., G. R. & I. Ry., Grand Rapids, Mich.
McKibben, Robert, Mast. Carp., P. R. R., Altoona, Pa.
McLean, Neil, Mast. Carp., Erie R. R., Huntington, Ind.
McLeod, Angus M., For. B. & B., Sou. Pac. Co., Oakland, Cal.
McMahon, J., Supvr. B. & B., G. T. Ry., Belleville, Ont.
McNab, A., Supvr. B. and B., P. M. R. R., Holland, Mich.
McNaughton, H. C., Div. For. B. & B., B. & M. R. R., Concord, N. H.
McQueen, A., Gen. For. Brs., D. L. & W. R. R., Binghamton, N. Y.
McRae, D. A., Carp. For., C. P. R., Lethbridge, Alberta.
McVay, A. B., Supvr. B. and B., L. & N. R. R., Evansville, Ind.
Mellgren, J., For. W. S., C. & N. W. Ry., Eagle Grove, Iowa.
Meloy, E. S., Asst. Engr., C. M. & St. P. Ry., Chicago.

Mercier, A. T., Div. Engr., Sou. Pac. Co., Los Angeles, Cal.
Meyer, H. W., R. M. D. Box 1, Glennevis, Ontario.
Meyers, W. F., For. B. and B., C. & N. W. Ry., Boone, Iowa.
Middleton, R. J., Val. Engr., C. M. & St. P. Ry., Chicago, Ill.
Miller, A. F., Mast. Carp., Penn. Lines W. of Pitts., Chicago.
Miller, J. W., Archt., C. & N. W. Ry., Chicago.
Mills, R. P., Supvr. Bldgs., N. Y. C. R. R., New York City.
Mines, Chas., Gen. For. B. & B., C. St. P. M. & O. Ry., Emerson, Neb.
Mitchell, G. A., Supt. B. and B., G. T. Ry., Toronto, Ont.
Moen, J. D., Supt. B. & B., C. St. P. M. & O. Ry., St. Paul, Minn.
Montzheimer, A., Ch. Engr., E. J. & E. Ry., Joliet, Ill.
Moore, E. G., For. Carpenter, B. & O. R. R., Flatwoods, W. Va.
Moore, W. H., Eng. of Brgs., N. Y. N. H. & H. R. R., New Haven, Conn.
Morgan, Homer, For. B. & B., P. M. R. R., Greenville, Mich.
Morrison, E. C., Div. Engr., Sou. Pac. Co., San Francisco.
Mountain, G. A., Ch. Engr., Ry. Com. of Canada, Ottawa, Ont.
Mountfort, Albert, Div. For. B. and B., B. & M. R. R., Nashua, N. H.
Mulcahy, W. H., For. B. & B., C. & N. W. Ry., Adams, Wis.
Munson, S. P., Chief Clerk, I. C. R. R., Mattoon, Ill.
Murphy, J. J., For. Water Service, Sou. Pac. Co., Oakland, Cal.
Murray, J. R., Supvr. B. & B., A. G. S. R. R., Tuscaloosa, Ala.
Murray, Edwd., Asst. Engr. B. & B., C. M. & St. P. Ry., Miles City, Mont.
Musgrave, C. T., For. B. & B., O. S. L. R. R., Idaho Falls, Idaho.
Musser, D. G., Mast. Carp., Penn. Lines W. of Pitts., Wellsville, Ohio.

Nelson, J. C., Engr. M. of W., S. A. L. Ry., Norfolk, Va.
Nelson, O. T., Supt. M. of W., A. & W. P. R. R., Atlanta, Ga.
Nelson, P. N., Gen'l For. of Carp., S. P. Co., San Francisco, Cal.
Newton, E. O., Div. For. Bldgs., N. Y. N. H. & H. R. R., Danbury, Conn.
Newton, R., For. B. & B., O. S. L. R. R., Pocatello, Idaho.
Nies, A. B., Archt., M. C. R. R., Jackson, Mich.
Noland, W. B., Supvr. B. & B., O. A. & E. Ry., Sacramento, Cal.
Noon, W. M., 617 Ave. G., Miami, Fla.
Nuelle, J. H., Chief Engr., N. Y. O. & W. R. R., Middletown, N. Y.

O'Connor, W. F., Supvr. Bridges, L. I. R. R., Flushing, N. Y.
O'Neill, P. J., Mast. Carp., N. Y. C. R. R., Adrian, Mich.
Osborn, F. C., Consulting Engineer, 740 Engineer's Bldg., Cleveland, O.
Owen, John, For. B. & B., D. & M. Ry., East Tawas, Mich.

Page, A. A., Div. For. B. & B., B. & M. R. R., Lowell, Mass.
Parker, J. F., Gen. For. B. & B., A. T. & S. F. Ry., San Bernardino, Cal.
Parker, W. V., For. Union Br. & Const. Co., Metropolis, Ill.
Parks, J., 3347 Boulevard F., Denver, Colo.
Parsons, P. E., For. B. & B., O. S. L. R. R., Salt Lake City.
Paterson, E. E., Plumber For., O. S. L. R. R., Pocatello, Idaho.
Patterson, S. F., Secretary Emeritus, Concord, N. H.
Pauba, A. W., For. B. and B., C. & S. Ry., Denver, Colo.
Peabody, K., Asst. Supv. Bldgs., N. Y. C. & H. R. R. R., New York City.
Penwell, J. N., Supvr. B. and B., L. E. & W. Ry., Tipton, Ind.
Perkins, H. D., 1501 Walnut St., Danville, Ill.
Pettis, W. A., Gen. Supv. Bldgs., N. Y. C. R. R., Rochester, N. Y.
Phillips, B. P., Asst. Supvr. B. and B., N. Y. N. H. & H. R. R., Willimantic, Conn.
Pickering, B. F., Supvr. B. & B., B. & M. R. R., Salem, Mass.
Pickering, F. M., Div. For. B. & B., B. & M. R. R., Salem, Mass.
Pinson, J. F., Asst. Engr. B. & B., C. M. & St. P. Ry., Seattle, Wash.
Pierce, Roy, Mast. Carp., Erie R. R., Salamanca, N. Y.
Piper, E. B., For. B. & B., B. & M. R. R., Concord, N. H.
Pitcher, C. G., For. B. & B., O. S. L. R. R., Pocatello, Idaho.

Plank, D. E. Supvr. B. and B., Pac. Elec. Ry., Los Angeles, Cal.
Pollard, Harry, Asst. Gen'l Br. Insp., S. P. Co., San Francisco, Cal.
Pollard, Homer, Bridge Inspr., Sou. Pac. Co., West Oakland, Cal.
Pollock, H. H., Mast. Carp. of Bldgs., P. C. C. & St. L. Ry., Carnegie, Pa.
Porter, L. H., Box 35, Andover, Conn.
Potts, J. O., M. of W. Inspr., B. & O. R. R., Baltimore, Md.
Powell, C. E., Genl. Insp. Brgs., C. & O. Ry., Hinton, W. Va.
Powell, S. J., Div. For. B. & B., O. S. L. R. R., Ogden, Utah.
Powers, G. F., Contractor, Joliet, Ill.

Quinn, William, Supt. B. & B., St. L. S. W. Ry., of T., Tyler, Tex.

Rankin, W. F., Mast. Carp., Pa. Lines West, Cambridge, Ohio.
Ranney, J. E., Genl. For. B. & B., D. L. & W. R. R., Buffalo, N. Y.
Rask, A. G., Supvr. B. & B., C. St. P. M. & O. Ry., Altoona, Wis.
Ratliff, W. L., Supvr. B. & B., I. C. R. R., Chicago, Ill.
Rear, G. W., Gen'l Insp., S. P. Co., San Francisco, Cal.
Redfield, J. A. S., Div. Engr., C. & N. W. Ry., Fond du Lac, Wis.
Redinger, C. A., Res. Engr., Sou. Ry., Knoxville, Tenn.
Redmond, C. E., Supvr. B. & B., St. L. I. M. & S. Ry., Van Buren, Ark.
Reid, R. H., Supvr. Bridges, N. Y. C. R. R., Cleveland, Ohio.
Reid, Wm., Timber Insp., I. C. R. R., Grenada, Miss.
Replogle, J. S., For. B. & B., Sou. Pac. Co., Oakland, Cal.
Rettinghouse, H., Ch. Engr., C. St. P. M. & O. Ry., St. Paul, Minn.
Reynolds, A. L., Inspr., L. V. R. R., New York City.
Reynolds, A. W., Genl. For., Carp. & Ptrs., P. R. R., New York City.
Reynolds, J. V., For. B. & B., St. L. I. M. & S. Ry., McGehee, Ark.
Rice, A. P., Roadmaster, C. N. & L. R. R., Columbia, S. C.
Rich, B. D., Painter For., Sou. Pac. Co., Stockton, Cal.
Richardson, R. W., Div. Engr., C. & N. W. Ry., Sioux City, Ia.
Ridgway, Arthur, Asst. Ch. Engr., D. & R. G. R. R., Denver, Colo.
Riney, M., Gen'l For. B. and B., C. & N. W. Ry., Baraboo, Wis.
Rintoul, D. T., Gen'l For. B. and B., Sou. Pac. Co., Bakersfield, Cal.
Robertson, A. A., Supr. B. and B., N. W. Pac. Ry., San Rafael, Cal.
Robinson, A. L., Br. Inspr., Sou. Pac. Co., Stockton, Cal.
Robinson, A. W., Asst. Engr., O. S. L. R. R., Salt Lake City.
Robinson, J. S., Div. Engr., C. & N. W. Ry., Chicago.
Robinson, John, Supvr. B. and B., P. M. R. R., Grand Rapids, Mich.
Robinson, R. B., Div. Engr., O. S. L. R. R., Pocatello, Idaho.
Rodman, G. A., Supt. B. & B., N. Y. N. H. & H. R. R., New Haven, Conn.
Rogers, W. A., Civil Engineer, 37 W. Van Buren St., Chicago.
Rohbock, W. L., Ch. Engr., W. & L. E. R. R., Cleveland, Ohio.
Roper, D. L., For. B. & B., St. L. I. M. & S. Ry., Monroe, La.
Rose, Norman, Supvr. B. and B., Sou. Pac. Co., Portland, Ore.
Rose, W. M., For. Water Service, Sou. Pac. Co., Sacramento, Cal.
Ross, William, Chief Carp., C. M. & St. P. Ry., Millbank, S. D.
Rounseville, D., Eng. Maint., C. & N. W. Ry., Chicago.
Roy, C. M., Gen. Bridge For., L. & N. R. R., Birmingham, Ala.
Ruge, Aug., Supvr. B. & B., C. St. P. M. & O. Ry., Mankato, Minn.
Rykenboer, E. J., Supvr. Bldgs., N. Y. C. R. R., Rochester, N. Y.

Salisbury, J. W., Gen. For. D. & W., A. C. L. R. R., Port Tampa, Fla.
Sampson, G. T., Asst. Engr., N. Y. N. H. & H. R. R., Boston.
Sattley, R. C., Valuation Engr., C. R. I. & P. Ry., Chicago.
Scannell, D. W., For. B. & B., S. P. L. A. & S. L. R. R., Salt Lake City.
Schall, F. E., Bridge Engr., L. V. R. R., So. Bethlehem, Pa.
Scheetz, F. B., Dept. Valuation, I. C. C., Kansas City, Mo.
Schoolcraft, C. H., For. Brgs., C. Vt. R., Farnham, Que.
Schuessler, W. B., Supvr. B. & B., N Y N H & H R. R., Waterbury, Conn.
Scott, Chas., Supvr. B. & B., B. R. & P. Ry., E. Salamanca, N. Y.

Scribner, C. J., Bldg. Inspr., C. B. & Q. Ry., Chicago.
Searls, Niles, Gen. Fire Inspector, Sou. Pac. Co., San Francisco, Cal.
Secord, Fred, For. B. & B., Sou. Pac. Co., Sacramento, Cal.
Sedmoradsky, C., Asst. For. B. & B., C. St. P. M. & O. Ry., Altoona, Wis.
Sedwell, G. W., Tunnel For., Sou. Pac. Co., Bakersfield, Cal.
Seeley, L. T., For. B. & B., A. T. & S. F. Ry., Needles, Cal.
Seely, S. A., Supvr. B. & B., N. Y. C. R. R., Watertown, N. Y.
Self, E. P., Supv. Bldgs., L. I. R. R., Jamaica, N. Y.
Selig, A. C., Ch. Archt., Intercolonial Ry., Moncton, N. B.
Sellew, W. H., Valuation Dept., M. C. R. R., Detroit, Mich.
Shane, A., Box 71, Indianapolis, Ind.
Shanklin, F. E., Gen. For., C. & N. W. Ry., Belle Plaine, Iowa.
Sharpe, D. W., Supv. B. & B., N. Y. N. H. & H. R. R., New Haven, Conn.
Sharpe, T. E., Supvr. B. and B., Sou. Ry., Greenville, S. C.
Sheldon, J. B., Supv.r. B. & B., N. Y. N. H. & H. R. R., Providence, R. I.
Sheley, Wm., Asst. Supvr. B. and B., L. & N. R. R., Evansville, Ind.
Shifflit, Parker, For. Br. Erec., O. S. L. R. R., Pocatello, Idaho.
Shope, D. A., Gen'l For. B. and B., A. T. & S. F. Ry., Fresno, Cal.
Shropshire, W., Supvr. of B. and B., Y. & M. V. R. R., Greenville, Miss.
Sibley, C. A., Engr. & Contr., 902 Chapel St., New Haven, Conn.
Siefer, F. M., Ch. Engr., Corvallis & Eastern R. R., Portland, Ore.
Simmons, I. L., Br. Engr., C. R. I. & P. Ry., Chicago.
Sinclair, E. L., Asst. Engr., C. M. & St. P. Ry., Marion, Iowa.
Sisson, F. P., Asst. Engr., G. T. Ry., Detroit, Mich.
Skeoch, Jas., Gen. For. B. & B., D. L. & W. R. R., Dunmore, Pa.
Smith, C. E., Consulting Engr., 2075 Ry. Exch. Bldg., St. Louis, Mo.
Smith, C. U., Asst. Engr., C. M. & St. P. Ry., Milwaukee, Wis.
Smith, C. W., Asst. Supvr. B. & B., Sou. Pac. Co., Portland, Ore.
Smith, E. U., Asst. Engr., W. & L. E. R. R., Cleveland, O.
Smith, E. W., Architect Val., M. C. R. R., Detroit, Mich.
Smith, G. W., American Bridge Co., Chicago.
Smith, M. A., Gen. For. B. & B., I. C. R. R., New Orleans, La.
Smith, Wm., For. W. S., St. L. I. M. & S. Ry., McGehee, Ark.
Snow, J. P., 1120 Kimball Bldg., Boston, Mass.
Snyder, A. C., D. & R. G. R. R., Salt Lake City, Utah.
Snyder, A. M., Supv. B. & B., L. & N. E. R. R., Pen Argyl, Pa.
Soisson, J. L., Gen'l For. B. and B., N. Y. C. R. R., Norwalk, Ohio.
Sorensen, Wm., For. B. & B., O. S. L. R. R., Brigham, Utah.
Spencer, Jos., For. B. & B., G. T. Ry., Stratford, Ont.
Spencer, William, Gen'l For. B. and B., C. & N. W. Ry., Norfolk, Neb.
Stamler, H., Supvr. B. & B., L. & N. R. R., Paris, Ky.
Stannard, James, 1602 Broadway, Kansas City, Mo.
Staten, J. M., Gen'l Bridge Insp., C. & O. Ry., Richmond, Va.
Steffens, W. F., Special Engr., N. Y. C. Lines, New York City.
Stelle, C. A.
Stern, I. F., C. E., Old Colony Bldg., Chicago.
Stevens, A. R., For. B. and B., O. S. L. R. R., Pocatello, Idaho.
Stewart, G. H., Master Mason, B. R. & P. Ry., Salamanca, N. Y.
Stewart, John, Gen. For. B. & B., C. St. P. M. & O. Ry., Spooner, Wis.
Stewart, W A., For. Brgs., C. Vt. R. R., New London, Conn.
Stewart, W. G., Supvr. B. and B., L. & N. R. R., Nashville, Tenn.
Stone, L. W., Supvr. B. & B., N. Y. C. R. R., Oswego, N. Y.
Storck, E. G., Mast. Carp., P. & R. Ry., Philadelphia, Pa.
Strothers, R. R., Asst. Engr., C. & St. P. M. & O. Ry., St. Paul, Minn.
Strouse, W. F., Asst. Engr., B. & O. R. R., 400 Forest Road, Baltimore.
Stuart, H. B., Struct. Engr., G. T. Ry., Montreal, Que.
Stuart, T. J., Supvr. B. and B., W. Pac. Ry., Elko, Nev.
Sullivan, William, Care Div. Engr., Mo. Pac. Ry., **Kansas City, Mo.**
Suter, O. M., Supvr. B. & B., I. C. R. R., Chicago.
Swain, G. F., Prof. C. E., Harvard University, **Cambridge, Mass.**
Swallow, W. A., Ch. Engr., Ga. & Fla. Ry., Augusta, Ga.

Swan, L. W., Supvr. B. and B., L. V. R. R., Easton, Pa.
Swartz, A., Vice Pres., Toledo & Western R. R., Sylvania, Ohio.
Swartz, H. C., Master B. & B., G. T. R., St. Thomas, Ont.
Sweeney. Wm., For. B. and B., C. & N. W. Ry., Green Bay, Wis.
Swenson, P., Supt. B. and B., M. St. P. & S. Ste. M. Ry., Minneapolis.
Sydell, A. C., Chief Draftsman, C. B. & Q. R. R., Chicago, Ill.

Talbott, J. L., Gen'l For. B. and B., A. T. & S. F. Ry., Pueblo, Col.
Tanner, F. W., Insp. M. of W., Mo. Pac. Ry., St. Louis, Mo.
Tanner, S. C., Mast. Carp., B. & O. R. R., Baltimore, Md.
Tattershall, E. R., Supvr. B. & B., N. Y. C. R. R., Malone, N. Y.
Taylor, D. B., Mast. Carp., B. & O. R. R., Garrett, Ind.
Taylor, F. A., Mast. Carp., B. & O. R. R., Cumberland, Md.
Taylor, Herbert, Supvr. B. and B., D. & R. G. R. R., Alamosa, Colo.
Taylor, J. C., Supvr. B. and B., N. P. Ry., Glendive, Mont.
Taylor, J. J., Supt. B. & B., K. C. S. Ry., Texarkana, Tex.
Teaford, J. B., Supvr. B. & B., Sou. Ry., Louisville, Ky.
Templin, E. E., For. Carp., P. & R. Ry., Pottsville, Pa.
Tewksbury, D. G., Supvr. B. & B., St. L. I. M. & S. Ry., Gorham, Ill.
Thomas, C. E., Contractor, Waukesha, Wis.
Thomas, M. E., Div. Engr., C. & N. W. Ry., Boone, Iowa.
Thomas, T. E., Mast. Carp., B. & O. R. R., Wilmington. Del.
Thompson, C., Supt. B. and B., E. J. & E. Ry., Joliet, Ill.
Thompson, C. S., Supt. B. and B., D. & R. G. R. R., Denver.
Thompson, E. E., G. F. B. & B., A. E. R. R., Phœnix, Ariz.
Thompson, F. L., Asst. Ch. Engr., I. C. R. R., Chicago.
Thompson, H. C., Div. Engr., N. Y. C. R. R., Weehawken, N. J.
Thompson, J. L., Gen. Insp. B. & B., D. & R. G. R. R., Salt Lake City.
Thorn, J. O., C. B. & Q. R. R., Beardstown, Ill.
Thorn, S. B., Div. For. Bldgs., M. C. R. R., Bay City, Mich.
Tichbourne, W. H., Supvr. B. & B., G. T. Ry., London, Ont.
Toohey, J. E., Gen'l For. B. and B., P. M. R. R., Grand Rapids, Mich.
Trapnell, Wm., V. P. & G. M., H. S. R. R., Romney, W. Va.
Tratman, E. E. R., Editor, Eng. News, Monadnock Blk., Chicago, Ill.
Travis, J. E., Pinehurst, Wash.
Travis, J. H.
Tretheway, Thos., For. B. & B., Sou. Pac. Co., Stockton, Cal.
Troup, G. A., Engr., Govt. Rys., Wellington, N. Z.
Turnbull, T. B., Supt. B. & B., A. A. R. R., Owosso, Mich.
Tyers, W. J., Supvr. B. & B., G. T. Ry., Montreal, Que.

Ullery, O. E., Asst. Engr., C. & N. W. Ry., Sioux City, Ia.
Urbutt, C. F., Asst. Engr., C. M. & St. P. Ry., Chicago, Ill.

Van Auken, A. M., 119 E. 18th St., Chicago.
Vance W. H., Engr. M. of W., La. & Ark. Ry., Stamps, Ark.
Vaughan, James, Supvr. B. and B., D. & R. G. R. R., Salida, **Colo.**
Vincent, E. J., For. B. & B., Sou. Pac. Co., Los Angeles.

Wackerle, L. J., Supvr. B. & B., Mo. Pac. Ry., Osawatomie, Kans.
Wagner, R., Gen. For. B. & B., M. & N. A. R. R., Harrison, Ark.
Waits, A. L., For. B. and B., St. L. I. M. & S. Ry., St. Louis, Mo.
Walker, I. O., Div. Engr., W. & A. R. R., Atlanta, Ga.
Wallenfelsz, J., Mast. Carp., Pa. Lines W., Cambridge, O.
Walther, C. H., Supvr. B. & B., Mo. Pac. Ry., Poplar Bluff, Mo.
Warcup, C. F., For. W. S., G. T. R., St. Thomas, Ont.
Watson, P. N., Supvr. B. and B., Maine Central R. R., Brunswick, Me.
Webb, Geo. H., Ch. Engr., M. C. R. R., Detroit, Mich.
Wehlen, Charles, Br. Inspr., L. I. R. R., Jamaica, N. Y.
Weir, C. F., Supvr. B. & B., P. M. R. R., St. Thomas, Ont.

Weise, F. E., Chief Clerk, Eng. Dept., C. M. & St. P. Ry., Chicago.
Weldon, A., For. B. & B., Sou. Pac. Co., Los Angeles, Cal.
Welker, G. W., Supvr. B. and B., Southern Ry., Alexandria, Va.
Wells, A. A., R. M. and Supvr. B. & B., Sou. Ry., Winston-Salem, N. C
Wells, D. T., For. B. and B., O. S. L. R. R., Salt Lake City, Utah.
Wells, L. N., Div. For., B. & M. R. R., Concord, N. H.
Wenner, E. R., Supvr. B. and B., L. V. R. R., Ashley, Pa.
Wester, C. A., Div. Engr., Sou. Pac. Co., Dunsmuir, Cal.
Wheaton, L. H., Div. Engr., Intercolonial Ry., Dartmouth, N. S.
Wherren, F. M., For. B. & B., B. & M. R. R., Portsmouth, N. H.
White, F. W., Supvr. B. & B., L. V. R. R., Sayre, Pa.
White, I. F., Engr. M. of W., C. G. W. R. R., Chicago.
White, J. B., For. W. S., C. & N. W. Ry., Boone, Ia.
Whiting, B. F., El Paso, Tex.
Whitmee, G. Y., For. W. S., P. M. R. R., Grand Rapids, Mich.
Whitney, W. C., Sen. Archt., I. C. C., 58 Judkins St., Newtonville, Mass.
Wicks, Warren, Gen'l For., L. I. R. R., Amityville, N. Y.
Wilkinson, J. M., Supvr. B. and B., C. N. R. R., Van Wert, Ohio.
Wilkinson, W. H., Bridge Insp., Erie R. R., Elmira, N. Y.
Williams, J. C., Supvr., Georgia R. R., Covington, Ga.
Williams, M. R., Gen. For. B. & B., A. T. & S. F. Ry., Las Vegas, N. M.
Wilson, E. E., Supvr. of Bridges, N. Y. C. R. R., New York City (81 E. 125th St.).
Wilson, J., Supvr. B. & B., G. T. Ry., Hamilton, Ont.
Wilson, M. M. Div. Br. Inspr., Sou. Pac. Co., Los Angeles
Wilson, W. W., Div. Engr., G. C. & S. F. Ry., Galveston, Tex.
Winter, A. E., Asst. Engr., C. St. P. M. & O. Ry., St. Paul.
Winter, J. L., Mast. Carp., S. A. L. Ry., Waldo, Fla.
Wise, E. F., 207 Clay St., Waterloo, Iowa.
Wishart, J. J., Supvr. B. & B., N. Y. N. H. & H. R. R., Hartford, Conn.
Witt, C. C., Dist. Engr., I. C. C., 1020 McGee St., Kansas City, Mo.
Wolf, A. A., Dist. Carp., C. M. & St. P. Ry., Milwaukee, Wis.
Wood, J. P., Supvr. B. & B., P. M. R. R., Saginaw, Mich.
Wood, J. W., Gen'l For. B. and B., A. T. & S. F. Ry., Needles, Cal.
Wood, W. E., Dist. Engr., C. M. & St. P. Ry., Chicago.
Wright, C. W., Mast. Carp., L. I. R. R., Jamaica, N. Y.
Wright, G. A., Gen. For. B. & B., Ill. Trac. Sys., Decatur, Ill.

Yappen, Adolph, Dist. Carp., C. M. & St. P. Ry., Chicago.
Yates, J. P., Gen. For. B. & B., N. O. T. & M. R. R., DeQuincy, La.
Yereance, W. B., Cons. Engr., 128 Broadway, New York City.
Young, R. C., Chief Engr., L. S. & I. Ry., Marquette, Mich.

Zinsmeister, E. C., Mast. Carp., B. & O. R. R., Zanesville, O.
Zook, D. C., Mast. Carp., Pa. Lines W. of Pitts., Ft. Wayne, Ind.

Total number of members 663.

LIFE MEMBERS.

Austin, C. P., 107 Park St., Medford, Mass.
Carmichael, Wm., St. J. & G. I. R. R., St. Joseph, Mo.
Carpenter, J. T., 345 No. Bartlett St., Medford, Ore.
Cummin, Jos. H., Bay Shore, N. Y.
Findley, A., 929 Wash. Ave., Portland, Me.
Gooch, C. W., 1325 W. 9th St., Des Moines, Ia.
Green, E. H. R., Texas Midland R. R., Terrell, Tex.
Hanks, G. E., E. Saginaw, Mich.
Hubbard, A. B., 32 Banks St., West Somerville, Mass.
Killam, A. E., Moncton, N. B.
Loughery, E., Gen. For. B. & B., T. & P. Ry., Dallas, Tex.
Lydston, W. A., Swampscott, Mass.
Mackenzie, W. B., C. E., Moncton, N. B.
McLean, Neil, Mast. Carp., Erie R. R., Huntington, Ind.
Mountain, G. A., Ch. Engr., Ry. Com. of Canada, Ottawa, Ont.
Noon, W. M., Miami, Fla.
Parks, Jas., U. P. R. R., Denver, Colo.
Patterson, S. F. (Sec. Emeritus), Concord, N. H.
Porter, L. H., Box 35, Andover, Conn.
Ross, Wm., C. M. & St. P. Ry., Millbank, So. Dak.
Shane, A., Box 71, Indianapolis, Ind.
Snow, J. P., 1120 Kimball Bldg., Boston, Mass.
Stannard, Jas., 1602 Broadway, Kansas City, Mo.
Tanner, Frank, Mo. Pac. Ry., St. Louis, Mo.
Thorn, J. O., C. B. & Q. R. R., Beardstown, Ill.
Wise, E. F., 207 Clay St., Waterloo, Ia.

DECEASED MEMBERS.

Aldrich, G.
Amos, A.,
Andrews, O. H.
Berg, Walter G.
Bishop, Geo. J.
Blair, J. A.
Bowman, A. L.
Brady, James
Carr, Charles
Causey, T. A.
Cleaveland, H. D.
Costolo, J. A.
Crane, Henry
DeMars, James
Dunlap, H.
Edinger, F. S.
Ewart, John
Fletcher, H. W.
Forbes, Jno.
Foreman, John
Fuller, C. E.
Gilbert, J. D.
Gilchrist, E. M.
Graham, T. B.
Hall, H. M.
Harwig, W. E.
Heflin, R. L.
Henson, H. M.
Hinman, G. W.
Holmes, H. E.
Hubley, John
Humphreys, Thos.
Isadell, L. S.
Johnson, J. E.
Keen, Wm. H.
Lantry, J. F.
Large, C. M.
Larson, G.
Lovett, J. W.
Mallard, C. C.
Markley, Abel S.
McCormack, J. W.
McGehee, G. W.
McIlwain, J. T.
McIntyre, Jas.
Mellor, W. J.
Millner, S. S.
Mitchell, J. B.
Mitchell, W. B.
Morgan, J. W.
Morgan, T. H.
Morrill. H. P.
Peck, R. M.
Perry, W. W.
Phillips, H. W.
Powell, W. T.
Reid, G. M.
Renton, Wm.
Reynolds, E. F.
Robertson, Daniel
Schaffer, J.
Schenck, W. S.
Schwartz, J. C.
Soles, G. H.
Spafford, L. K.
Spangler, J. A.
Spaulding, E. C.
Spencer, C. F.
Taylor, J. W.
Thompson, N. W
Tozzer, Wm. S.
Trautman, T. J.
Travis, O. J.
Vandegrift. C. W.
Van Der Hoek, J.
Wallace, T. E.
Walden, W. D.
Welch, E. T.
Wells, J. M.
Wood, W. B.
Worden, C. G.

MEMBERSHIP AND MILEAGE OF RAILWAYS REPRESENTED.

Name of Road and Membership.	Members.	Mileage
Alabama, Great Southern R. R.,	1	361
J. R. Murray, Tuscaloosa, Ala.		
Algoma Central & Hudson Bay Ry.	1	332
R. S. McCormick, Sault Ste. Marie, Ont.		
Ann Arbor R. R.,	1	292
T. B. Turnbull, Owosso, Mich.		
Arizona Eastern R. R.	1	373
E. E. Thompson, Phœnix, Ariz.		
Atchison, Topeka & Santa Fé Ry.,	5	5,968
Julius Froese, La Junta, Colo.		
A. J. James, Topeka, Kans.		
E. McCann, Wellington, Kans.		
John L. Talbott, Pueblo, Colo.		
M. R. Williams, Las Vegas, N. M.		
Atchison, Topeka & Santa Fé Ry. (Coast Lines)	6	2,053
E. E. Ball, Winslow, Ariz.		
J. H. Grover, Needles, Cal.		
J. F. Parker, San Bernardino, Cal.		
L. T. Seeley, Needles, Cal.		
D. A. Shope, Fresno, Cal.		
J. W. Wood, Needles, Cal.		
Atlanta & West Point R. R. and W. Ry. of Ala.	1	225
O. T. Nelson, Atlanta, Ga.		
Atlantic Coast Line R. R.	1	4,697
J. C. Williams, Opelika, Ala.		
J. W. Salisbury, Port Tampa, Fla.		
Baltimore & Ohio R. R. (System)	21	6,627
G. W. Andrews, Baltimore, Md.		
S. H. Blowers, Columbus, O.		
W. S. Bouton, Baltimore, Md.		
Z. T. Brantner, Martinsburg, W. Va.		
H. R. Bricker, Baltimore, Md.		
W. M. Clark, Pittsburgh, Pa.		
R. Henderson, Garrett, Ind.		
W. T. Hopke, Grafton, W. Va		
A. T. Humbert, New Castle Jct., Pa.		
E. G. Lane, Cincinnati, O.		
M. A. Long, Baltimore, Md.		
B. S. Mace, Baltimore, Md.		
Chas. Esping, Chicago, Ill.		

Name of Road and Membership.	Members.	Mileage.
Baltimore & Ohio R. R. (System). Continued.		
E. G. Moore, Grafton, W. Va.		
J. O. Potts, Baltimore, Md.		
W. F. Strouse, Baltimore, Md.		
S. C. Tanner, Baltimore, Md.		
D. B. Taylor, Garrett, Ind.		
F. A. Taylor, Cumberland, Md.		
T. E. Thomas, Wilmington, Del.		
E. C. Zinsmeister, Zanesville, O.		
Bangor & Aroostook R. R.	2	628
W. E. Alexander, Houlton, Me.		
M. Burpee, Houlton, Me.		
Bessemer & Lake Erie R. R.	1	210
H. H. Harman, Greenville, Pa.		
Boston & Albany R. R.	1	392
E. M. McCabe, Pittsfield, Mass.		
Boston & Maine R. R.	20	2,302
Cyrus P. Austin (retired), Medford, Mass.		
L. M. Blake, St. Johnsbury, Vt.		
J. E. Buckley, Nashua, N. H.		
J. P. Canty, Fitchburg, Mass.		
S. E. Dufort, Lowell, Mass.		
A. I. Gauthier, Concord, N. H.		
B. W. Guppy, Boston, Mass.		
Andrew B. Hubbard (retired), W. Somerville, Mass.		
F. J. Leavitt, Sanbornville, N. H.		
William A. Lydston (retired), Swampscott, Mass.		
John Marsh, Lawrence, Mass.		
H. C. McNaughton, Concord, N. H.		
Albert Mountfort, Nashua, N. H.		
A. A. Page, Lowell, Mass.		
S. F. Patterson (retired), Concord, N. H.		
B. F. Pickering, Salem, Mass.		
F. M. Pickering, Salem, Mass.		
E. B. Piper, Fitchburg, Mass.		
L. N. Wells, Concord, N. H.		
F. M. Wherren, Portsmouth, N. H.		
Buffalo, Rochester & Pittsburgh Ry.	3	586
E. W. Fair, Du Bois, Pa.		
Chas. Scott, E. Salamanca, N. Y.		
G. H. Stewart, E. Salamanca, N. Y.		
Canadian Northern Ry. System	1	7,018
J. A. Crawford, Saskatoon, Sask.		
Canadian Pacific Ry.	2	12,917
Frank Lee, Winnipeg, Man.		
D. A. McRae, Lethbridge, Alberta.		
Carolina & Northwestern Ry.	1	133
J. W. Fletcher, Chester, S. C.		
Central of Georgia Ry.	2	1,924
J. M. Fitzgerald, Macon, Ga.		
H. C. McKee, Macon, Ga.		
Central Vermont Ry.,	6	536
G. M. Cota, St. Albans, Vt.		
C. Donaldson, St. Albans, Vt.		

Name of Road and Membership.	Members.	Mileage.
Central Vermont Ry. Continued.		
C. F. Flint, St. Albans, Vt.		
C. R. Lyman, Waterbury, Vt.		
C. H. Schoolcraft, Farnham, Que.		
W. A. Stewart, New London, Conn.		
Chesapeake & Ohio Ry.	4	2,374
F. M. Griffith, Covington, Ky.		
Oscar L. Grover, Richmond, Va.		
C. E. Powell, Hinton, W. Va.		
J. M. Staten, Richmond, Va.		
Chicago & Eastern Illinois R. R.	1	1,282
A. S. Markley, Danville, Ill.		
Chicago & North Western Ry.,	35	8,102
L. J. Anderson, Escanaba, Mich.		
C. F. Bach, Belle Plaine, Ia.		
H. Bender, Eagle Grove, Ia.		
F. L. Burrell, Fremont, Neb.		
F. M. Case, Belle Plaine, Ia.		
O. F. Dalstrom, Chicago, Ill.		
T. H. Durfee, Huron, S. D.		
W. H. Finley, Chicago, Ill.		
M. J. Flynn, Chicago, Ill.		
F. N. Graham, Boone, Ia.		
G. W. Hand, Chicago, Ill.		
C. Herrig, Wall Lake, Ia.		
John Hunciker, Chicago, Ill.		
Lee Jutton, Madison, Wis.		
C. F. King, Omaha, Neb.		
B. R. Kulp, Antigo, Wis.		
C. A. Lichty, Chicago, Ill.		
J. A. Lorch, Chicago, Ill.		
George Loughnane, Escanaba, Mich.		
C. A. Marcy, Chicago, Ill.		
J. Mellgren, Eagle Grove, Ia.		
W. F. Meyers, Boone, Iowa.		
J. W. Miller, Chicago, Ill.		
W. H. Mulcahy, Adams, Wis.		
J. A. S. Redfield, Fond du Lac, Wis.		
R. W. Richardson, Sioux City, Ia.		
M. Riney, Baraboo, Wis.		
J. S. Robinson, Chicago, Ill.		
D. Rounseville, Chicago, Ill.		
F. E. Shanklin, Belle Plaine, Ia.		
Wm. Spencer, Norfolk, Nebr.		
W. M. Sweeney, Green Bay, Wis.		
M. E. Thomas, Boone, Ia.		
O. E. Ullery, Sioux City, Ia.		
J. B. White, Boone, Ia.		
Chicago, Burlington & Quincy R. R. Co.,	6	9,366
W. E. Elder, Burlington, Ia.		
W. Hurst, Chicago, Ill.		
W. T. Krausch, Chicago, Ill.		
C. J. Scribner, Chicago.		
A. C. Sydell, Chicago, Ill.		
J. O. Thorn, Beardstown, Ill.		
Chicago Great Western R. R.,	5	1,427
W. L. Derr, Clarion, Ia.		

Name of Road and Membership.	Members.	Mileage.
Chicago Great Western R. R. Continued.		
H. H. Eggleston, Des Moines, Ia.		
H. A. Elwell, Clarion, Ia.		
M. G. Manning, Ft. Dodge, Ia.		
I. F. White, Chicago, Ill.		
Chicago, Indianapolis & Louisville Ry.	1	578
J. M. Caldwell, Lafayette, Ind.		
Chicago, Milwaukee & St. Paul Ry.,	25	10,667
F. J. Auge, Wells, Minn.		
N. N. Barber, Ottumwa, Ia.		
A. J. Buck, Tacoma, Wash.		
E. E. Clothier, Mobridge, S. D.		
H. R. Drum, Mitchell, S. D.		
W. E. Duckett, Minneapolis, Minn.		
Chas. Gradt, Savanna, Ill.		
L. D. Hadwen, Chicago, Ill.		
F. E. King, Minneapolis, Minn.		
N. H. LaFountain, Chicago, Ill.		
W. R. Lanning, St. Maries, Idaho.		
C. F. Loweth, Chicago, Ill.		
T. E. McFadden, Cedar Falls, Wash.		
E. S. Meloy. Chicago.		
R. J. Middleton, Chicago, Ill.		
Edw. Murray, Miles City, Mont.		
J. F. Pinson, Seattle, Wash.		
William Ross, Milbank, S. D.		
E. L. Sinclair, Marion, Ia.		
C. U. Smith, Milwaukee, Wis.		
C. F. Urbutt, Chicago, Ill.		
Fred E. Weise, Chicago, Ill.		
A. A. Wolf, Milwaukee, Wis.		
William E. Wood, Chicago, Ill.		
A. Yappen, Chicago, Ill.		
Chicago, Rock Island & Pacific Ry.,	8	7,657
McClellan Bishop, El Reno, Okla.		
J. P. Copp, Haileyville, Okla.		
S. T. Corey, Chicago, Ill.		
C. H. Eggers, Little Rock, Ark.		
E. R. Floren, Rock Island, Ill.		
Guy Gordon, Little Rock, Ark.		
R. C. Sattley. Chicago.		
I. L. Simmons, Chicago, Ill.		
Chicago, St. Paul, Minneapolis & Omaha Ry.	12	1,750
J. G. Bock, St. Paul, Minn.		
A. F. Gilmon, St. Paul, Minn.		
J. F. Glasgow, Worthington, Minn.		
Chas. Mines, Emerson, Neb.		
J. D. Moen, Boone, Ia.		
A. G. Rask, Altoona, Wis.		
H. Rettinghouse, St. Paul, Minn.		
Aug. Ruge, Mankato. Minn.		
Chas. Sedmoradsky, Altoona, Wis.		
John Stewart, Spooner, Wis.		
R. R. Strothers, St. Paul, Minn.		
A. E. Winter, St Paul, Minn.		
Chicago, Terre Haute & Southeastern Ry.	2	351
J. Dupree, Crete, Ill.		
J. O. Jewell, Terre Haute, Ind.		

Name of Road and Membership.	Members.	Mileage.
Cincinnati, New Orleans & Texas Pacific Ry. F. J. Conn, Lexington, Ky. L. A. Cowsert, Danville, Ky.	2	338
Cincinnati Northern R. R. J. M. Wilkinson, Van Wert, O.	1	236
Colorado & Southern Ry., R. W. Beeson, Trinidad, Colo. C. W. Fellows, Denver, Colo. Harry James, Denver, Colo. A. W. Pauba, Denver, Colo.	4	1,089
Colorado Midland Ry. J. Guretzky, Colorado City, Colo.	1	338
Columbia, Newberry & Laurens R. R. A. P. Rice, Columbia, S. C.	1	75
Concho, San Saba & Llano Valley R. R. K. S. Hull, Temple, Tex.	1	61
Corvallis & Eastern R. R., W. E. Burns, Albany, Ore. F. M. Siefer, Portland, Ore.	2	142
Delaware, Lackawanna & Western R. R., F. J. Arnold, Scranton, Pa. G. E. Boyd, Buffalo, N. Y. E. Cahill, Binghamton, N. Y. C. G. Connolly, Buffalo, N. Y. A. McQueen, Binghamton, N. Y. J. E. Ranney, Buffalo, N. Y. Jas. Skeoch, Dunmore, Pa.	7	985
Denver & Rio Grande R. R., G. W. Kinney, Salt Lake City. A. Ridgway, Denver, Colo. A. C. Snyder, Salt Lake City. H. Taylor, Alamosa, Colo. C. S. Thompson, Denver, Colo. J. L. Thompson, Salt Lake City. Jas. Vaughan, Salida, Colo.	7	2,577
Detroit & Mackinac Ry. John Owen, East Tawas, Mich.	1	434
Duluth & Iron Range R. R. W. A. Clark, Duluth, Minn. B. T. McIver, Two Harbors, Minn.	2	197
Duluth, Missabe & Northern Ry., F. C. Baluss, Duluth, Minn. W. A. McGonagle, Duluth, Minn.	2	356
Duluth, South Shore & Atlantic Ry. E. R. Lewis, Duluth, Minn.	1	601
Elgin, Joliet & Eastern Ry. G. H. Jennings, Joliet, Ill. A. Montzheimer, Joliet, Ill. C. Thompson, Joliet, Ill.	3	770

Name of Road and Membership.	Members.	Mileage.
Erie R. R.	10	2,557
O. F. Barnes, Jersey City, N. J.		
W. O. Eggleston, Huntington, Ind.		
E. F. Gardner, Buffalo, N. Y.		
A. W. Harlow, Huntington, Ind.		
A. J. Horth, Meadville, Pa.		
F. A. Knapp, Jersey City, N. J.		
W. H. Matthews, Hornell, N. Y.		
Neil McLean, Huntington, Ind.		
Roy Pierce, Salamanca, N. Y.		
W. H. Wilkinson, Elmira, N. Y.		
Florida East Coast Ry.	1	708
E. K. Barrett, St. Augustine, Fla.		
Fort Smith & Western R. R.	1	217
B. F. Beckman, Ft. Smith, Ark.		
Fort Worth & Denver City Ry.	1	454
J. M. Mann, Ft. Worth, Tex.		
Galveston, Houston & Henderson R. R.,	1	50
F. W. Bailey, Galveston, Tex.		
Georgia R. R.,	1	307
J. C. Williams, Covington, Ga.		
Georgia & Florida Ry.	1	325
W. A. Swallow, Augusta, Ga.		
Grand Rapids & Indiana Ry.	2	592
H. M. Large, Ft. Wayne, Ind.		
W. S. McKeel, Grand Rapids, Mich.		
Grand Trunk Ry. System,	17	4,765
W. Cayley, Stratford, Ont.		
J. B. Gaut, Chicago, Ill.		
J. C. Gokey, Richmond, Que.		
J. Henderson, St. Thomas, Ont.		
J. Innes, Hamilton, Ont.		
J. H. Johnston, Montreal, Que.		
G. C. McCue, Ottawa, Ont.		
J. McMahon, Bellville, Ont.		
George A. Mitchell, Toronto, Ont.		
F. P. Sisson, Detroit, Mich.		
Jos. Spencer, Stratford, Ont.		
H. B. Stuart, Montreal, Que.		
H. C. Swartz, St. Thomas, Ont.		
W. H. Tichbourne, London, Ont.		
W. J. Tyers, Montreal, Que.		
C. F. Warcup, St. Thomas, Ont.		
J. Wilson, Hamilton, Ont.		
Grand Trunk Pacific Ry.	1	3,627
L. H. Wheaton, Dartmouth, N. S.		
Great Northern Ry.	1	8,102
J. A. Bohland, St. Paul, Minn.		
Gulf, Colorado and Santa Fé Ry.	4	1,937
E. C. George, Beaumont, Tex.		
K. S. Hull, Temple, Tex.		
W. G. Massenburg, Beaumont, Tex.		
W. W. Wilson, Galveston, Tex.		

Name of Road and Membership.	Members.	Mileage.
Hampshire Southern R. R. **W. Trapnell, Romney, W. Va.**	1	38
Illinois Central R. R., P. Aagaard, Chicago, Ill. F. O. Draper, Chicago, Ill. C. Ettinger, Chicago, Ill. Maro Johnson, Chicago, Ill. C. R. Knowles, Chicago, Ill. O. W. Lentz, Dubuque, Ia. R. J. McKee, Freeport, Ill. Samuel P. Munson, Mattoon, Ill. W. L. Ratliff, Chicago, Ill. William Reid, Grenada, Miss. M. A. Smith, New Orleans, La. O. M. Suter, Chicago, Ill. F. L. Thompson, Chicago, Ill. E. F. Wise (retired), Waterloo, Ia.	14	4,767
Illinois Traction System G. W. Black, Mackinaw, Ill. **G. A. Wright, Decatur, Ill.**	2	425
Intercolonial Ry. **Hugh Jardine, Moncton, N. B.** **A. C. Selig, Moncton, N. B.**	2	1,468
International & Great Northern Ry. **H. M. Jack, Palestine, Tex.**	1	1,106
Kansas City, Clinton & Springfield Ry. **J. B. Browne, Clinton, Mo.**	1	155
Kansas City Southern Ry. W. W. Casey, Texarkana, Tex. C. E. Johnston, Kansas City, Mo. **J. J. Taylor, Texarkana, Tex.**	3	826
Lake Erie & Western R. R., T. O. Andrews, Tipton, Ind. R. M. Bowman, Indianapolis, Ind. P. P. Lawrence, Tipton, Ind. **J. N. Penwell, Tipton, Ind.**	4	882
Lake Superior & Ishpeming Ry., Munising, Marquette & S. E. Ry. August Anderson, Marquette, Mich. Roscoe C. Young, Marquette, Mich.	2	160
Lehigh & Hudson River Railway **J. E. Barrett, Warwick, N. Y.**	1	96
Lehigh & New England R. R. A. M. Snyder, Pen Argyl, Pa.	1	296
Lehigh Valley R. R., **E. B. Ashby, New York City.** **Peter Hofecker, Auburn, N. Y.** **J. W. Holcomb, Buffalo, N. Y.** R. E. James, Hazelton, Pa. **Judson Joslin, Auburn, N. Y.** A. E. Kemp, Hazleton, Pa. A. L. Reynolds, New York City.	11	1,443

Name of Road and Membership.	Members.	Mileage.
Lehigh Valley R. R. Continued.		
F. E. Schall, South Bethlehem, Pa.		
L. W. Swan, Easton, Pa.		
E. R. Wenner, Ashley, Pa.		
F. W. White, Sayre, Pa.		
Long Island R. R.	6	399
M. Loeffler, Jamaica, N. Y.		
W. F. O'Connor, Flushing, N. Y.		
E. P. Self, Jamaica, N. Y.		
Chas. Wehlen, Jamaica, N. Y.		
W. Wicks, Amityville, N. Y.		
C. W. Wright, Jamaica, N. Y.		
Louisiana & Arkansas Ry.	1	545
W. H. Vance, Stamps, Ark.		
Louisville & Nashville R. R. (and Nash. Term. Co.)	11	5,034
J. M. Bibb, Birmingham, Ala.		
A. J. Catchot, Ocean Springs, Miss.		
R. O. Elliott, Nashville, Tenn.		
H. R. Hill, Birmingham, Ala.		
Floyd Ingram, Erin, Tenn.		
J. W. Little, Birmingham, Ala.		
A. B. McVay, Evansville, Ind.		
C. M. Roy, Birmingham, Ala.		
Wm. Sheley, Evansville, Ind.		
H. Stamler, Paris, Ky.		
W. G. Stewart, Nashville, Tenn.		
Maine Central R. R.	1	1,206
P. N. Watson, Brunswick, Me.		
Michigan Central R. R.	13	1,800
S. D. Bailey, Detroit, Mich.		
Grant Boyer, Detroit, Mich.		
G. H. Fenwick, St. Thomas, Ont.		
Thomas Hall, St. Thomas, Ont.		
F. J. Hodges, Jackson, Mich.		
Henry A. Horning, Jackson, Mich.		
J. S. Huntoon, Detroit, Mich.		
Andrew Leslie, St. Thomas, Ont.		
A. B. Nies, Jackson, Mich.		
W. H. Sellew, Detroit, Mich.		
E. W. Smith, Detroit, Mich.		
S. B. Thorn, Bay City, Mich.		
Geo. H. Webb, Detroit, Mich.		
Minneapolis & St. Louis R. R.	2	1,646
Ed. Gagnon, Minneapolis, Minn.		
G. S. Kibbey, Minneapolis, Minn.		
Minneapolis, St. Paul & Sault Ste. Marie Ry.	2	4,020
G. A. Manthey, Minneapolis, Minn.		
P. Swenson, Minneapolis, Minn.		
Miss. River & Bonne Terre Ry.	1	64
C. H. Fake, Bonne Terre, Mo.		
Missouri & North Arkansas R. R.,	1	365
R. Wagner, Harrison, Ark.		
Missouri, Kansas & Texas Lines,	1	3,865
A. S. Clopton, Oklahoma City, Okla.		

Name of Road and Membership.	Members.	Mileage.
Missouri Pacific Ry. System (including St. Louis, Iron Mountain & Southern Ry.)	31	7,293
E. E. Allard, St. Louis, Mo.		
T. H. Bridges, McGehee, Ark.		
Robert J. Bruce, St. Louis, Mo.		
W. L. Burnett, Eudora, Ark.		
J. E. Byrd, McGehee, Ark.		
L. J. Byrd, Dermott, Ark.		
W. E. Byrd, McGehee, Ark.		
H. R. DeWitt, Little Rock, Ark.		
A. H. Ferdina, St. Louis, Mo.		
C. Gnadt, Poplar Bluff, Mo.		
W. A. Guire, Lake Providence, La.		
Lon Graves, Dermott, Ark.		
J. C. Hargrove, McGehee, Ark.		
E. H. Harvey, Montrose, Ark.		
W. Hausgen, Sedalia, Mo.		
E. P. Hawkins, McGehee, Ark.		
W. J. Lacy, Poplar Bluff, Mo.		
C. W. Lamb, Pine Bluff, Ark.		
G. W. Land, McGehee, Ark.		
A. D. May, Little Rock, Ark.		
C. E. Redmond, Van Buren, Ark.		
J. V. Reynolds, McGehee, Ark.		
D. L. Roper, Monroe, La.		
C. E. Smith, St. Louis, Mo.		
Wm. Smith, McGehee, Ark.		
Wm. Sullivan, Kansas City, Mo.		
F. W. Tanner, St. Louis, Mo.		
D. G. Tewksbury, Gorham, Ill.		
L. J. Wackerle, Osawatomie, Kans.		
A. L. Waits, St. Louis, Mo.		
C. H. Walther, Poplar Bluff, Mo.		
Mobile & Ohio R. R.	1	1,122
W. B. Harris, Jackson, Tenn.		
Nashville, Chattanooga & St. Louis Ry.	2	1,230
Hunter McDonald, Nashville, Tenn.		
I. O. Walker, Paducah, Ky.		
National Rys. of Mexico	1	7,717
Hans Bentele, Mexico City, Mex.		
New Orleans, Mobile & Chicago R. R.	1	403
P. K. Lutken, Laurel, Miss.		
New Orleans, Texas & Mexico R. R.	1	287
J. P. Yates, DeQuincy, La.		
New South Wales Government Rys.,	1	3,967
James Fraser, Sydney, N. S. W.		
New York Central R. R.	18	5,032
Willard Beahan, Cleveland, O.		
J. K. Bonner, Rochester, N. Y.		
W. S. Haley, Toledo, O.		
U. S. Hitesman, New York City.		
G. J. Klumpp, Rochester, N. Y.		
R. P. Mills, New York City.		
Philip O'Neill, Adrian, Mich.		
Kemper Peabody, N. Y. City.		

Name of Road and Membership.	Members.	Mileage.
New York Central R. R. Continued.		
W. A. Pettis, Rochester, N. Y.		
R. H. Reid, Cleveland, O.		
E. J. Rykenboer, Rochester, N. Y.		
S. A. Seely, Watertown, N. Y.		
J. L. Soisson, Norwalk, O.		
W. F. Steffens, New York City.		
L. W. Stone, Oswego, N. Y.		
E. R. Tattershall, Malone, N. Y.		
H. C. Thompson, Weehawken, N. J.		
E. E. Wilson, New York City.		
New York, New Haven & Hartford R. R.	16	2,003
C. L. Beeler, New Haven, Conn.		
J. S. Browne, Providence, R. I.		
Eldridge E. Candee, Bridgeport, Conn.		
Elliot E. Candee, Waterbury, Conn.		
H. H. Kinzie, Taunton, Mass.		
A. G. McKay, New Haven, Conn.		
Wm. H. Moore, New Haven, Conn.		
E. O. Newton, Danbury, Conn.		
B. P. Phillips, Willimantic, Conn.		
L. H. Porter (retired), Andover, Conn.		
George A. Rodman, New Haven, Conn.		
George T. Sampson, Boston, Mass.		
W. B. Schuessler, Waterbury, Conn.		
D. W. Sharpe, New Haven, Conn.		
J. B. Sheldon, Providence, R. I.		
J. J. Wishart, Hartford, Conn.		
New York, Ontario & Western Ry.	1	494
J. H. Nuelle, Middletown, N. Y.		
New Zealand Government Rys.	2	2,717
C. H. Biss, Christchurch, N. Z.		
George A. Troup, Wellington, New Zealand.		
Northern Pacific Ry.,	4	6,313
James Hartley, Staples, Minn.		
F. Ingalls, Jamestown, N. D.		
C. S. McCully, Jamestown, N. D.		
J. C. Taylor, Glendive, Mont.		
North Western Govt. Rys. (India)	1	4,431
D. M. Cookson, Kalaw, Burma, India.		
Northwestern Pacific R. R.,	1	469
A. A. Robertson, San Rafael, Cal.		
Oakland, Antioch & Eastern Ry.	1	115
W. B. Noland, Sacramento, Cal.		
Oregon Short Line R. R.	26	2,256
E. S. Airmet, Salt Lake City, Utah.		
L. W. Althof, Pocatello, Idaho.		
N. D. Brookhart, Pocatello, Idaho.		
F. P. Cullen, Pocatello, Idaho.		
J. F. Cullen, Pocatello, Idaho.		
W. C. Dale, Pocatello, Idaho.		
E. A. Demars, Salt Lake City, Utah.		
I. A. Draper, Pocatello, Idaho.		
Fred Gaunt, Pocatello, Idaho.		
Rupert Hansen, Pocatello, Idaho.		

Name of Road and Membership.	Members.	Mileage.
Oregon Short Line R. R. Continued.		
C. J. Harris, Roberts, Idaho.		
C. A. Harshbarger, Ontario, Ore.		
J. A. Kelly, Pocatello, Idaho.		
A. H. King, Pocatello, Idaho.		
C. T. Musgrave, Idaho Falls, Idaho.		
R. Newton, Pocatello, Idaho.		
P. E. Parsons, Salt Lake City, Utah.		
E. E. Paterson, Pocatello, Idaho.		
C. G. Pitcher, Pocatello, Idaho.		
S. J. Powell, Ogden, Utah.		
A. W. Robinson, Salt Lake City, Utah.		
R. B. Robinson, Salt Lake City, Utah.		
Parker Shifflit, Pocatello, Idaho.		
Wm. Sorensen, Brigham, Utah.		
A. R. Stevens, Pocatello, Idaho.		
D. T. Wells, Salt Lake City, Utah.		
Pacific Electric Ry.	2	1,047
Alf Brown, Los Angeles.		
D. E. Plank, Los Angeles, Cal.		
Pennsylvania Lines West of Pittsburgh	9	3,098
Samuel C. Bowers, Steubenville, O.		
Stanton Bowers, Bradford, O.		
B. F. Gehr, Richmond, Ind.		
A. F. Miller, Chicago, Ill.		
D. G. Musser, Wellsville, O.		
H. H. Pollock, Carnegie, Pa.		
W. F. Rankin, Cambridge, O.		
J. Wallenfelsz, Cambridge, O.		
D. C. Zook, Fort Wayne, Ind.		
Pennsylvania R. R.	5	5,379
M. M. Barton, West Philadelphia, Pa.		
Richard G. Develin, Philadelphia, Pa.		
H. R. Leonard, Philadelphia, Pa.		
Robert McKibbon, Altoona, Pa.		
A. W. Reynolds, New York City.		
Pere Marquette R. R.	14	2,262
J. D. Black, Saginaw, Mich.		
Thos. Brown, Saginaw, Mich.		
J. J. Evans, Saginaw, Mich.		
Edw. Guild, Grand Rapids, Mich.		
G. E. Hanks (retired), East Saginaw, Mich.		
C. H. Johnson, Saginaw, Mich.		
A. L. McCloy, Reese, Mich.		
A. McNab, Holland, Mich.		
Homer Morgan, Greenville, Mich.		
John Robinson, Grand Rapids, Mich.		
J. E. Toohey, Grand Rapids, Mich.		
C. F. Weir, St. Thomas, Ont.		
G. Y. Whitmee, Grand Rapids, Mich.		
J. P. Wood, Saginaw, Mich.		
Philadelphia & Reading Ry.	4	1,582
Amos H. Beard (retired), Reading, Pa.		
Franklin Gable, Catawissa, Pa.		
E. G. Storck, Philadelphia, Pa.		
E. E. Templin, Pottsville, Pa.		

Name of Road and Membership.	Members.	Mileage.
Pittsburgh & Lake Erie R. R.	1	224
D. L. McKee, McKee's Rocks, Pa.		
Queen & Crescent Route	1	509
E. L. Loftin, Vicksburg, Miss.		
San Antonio & Aransas Pass Ry.	1	724
J. D. Lacy, Houston, Tex.		
San Pedro, Los Angeles & Salt Lake R. R.	4	1,075
F. M. Bigelow, Salt Lake City, Utah.		
R. R. Bishop, Salt Lake City, Utah.		
W. C. Frazier, Los Angeles, Cal.		
D. W. Scannell, Salt Lake City, Utah.		
Seaboard Air Line Ry.,	4	3,093
B. B. Christy, Tallahassee, Fla.		
W. J. Galloway, Hamlet, N. C.		
J. C. Nelson, Norfolk, Va.		
J. L. Winter, Waldo, Fla.		
St. Joseph & Grand Island Ry.	1	258
Wm. Carmichael, St. Joseph, Mo.		
St. Louis & San Francisco R. R.	1	4,740
F. G. Jonah, St. Louis, Mo.		
St. Louis Southwestern Ry.	2	1,685
J. S. Berry, St. Louis, Mo.		
Wm. Quinn, Tyler, Tex.		
Southern Ry.	12	7,022
D. A. Ballenger, Greenville, S. C.		
J. H. Blackwell, Columbia, S. C.		
R. E. Connor, Columbia, S. C.		
J. R. Fowlkes, Columbia, S. C.		
N. L. Hall, Greensboro, N. C.		
Joseph A. Killian, Jr., Charlotte, N. C.		
J. S. Lemond, Charlotte, N. C.		
C. A. Redinger, Knoxville, Tenn.		
T. E. Sharpe, Greenville, S. C.		
J. B. Teaford, Louisville, Ky.		
G. W. Welker, Alexandria, Va.		
A. A. Wells, Winston-Salem, N. C.		
Southern New England Ry.	3	85
J. E. Cole, Providence, R. I.		
R. D. Garner, Providence, R. I.		
A. Larsen, Melville, Mass.		
Southern Pacific Company	67	6,928
H. L. Archbold, Los Angeles, Cal.		
C. J. Astrue, San Francisco, Cal.		
T. W. Bratten, West Oakland, Cal.		
H. Bulger, Oakland Pier, Cal.		
W. H. Burgess, Stockton, Cal.		
D. Burke, Tucson, Ariz.		
F. L. Burkhalter, Portland, Ore.		
W E. Burns, Portland, Ore.		
J. T. Caldwell, Bakersfield, Cal.		
J. H. Clark, Los Angeles, Cal.		
W. S. Corbin, Los Angeles, Cal.		

Name of Road and Membership.	Members.	Mileage.
Southern Pacific Company. Continued.		
G. S. Crites, Tucson, Ariz.		
D. M. Crosman, Los Angles, Cal.		
Geo. Dickson, Oakland, Cal.		
F. C. Dittmar, Los Angeles, Cal.		
R. M. Drake, San Francisco, Cal.		
G. A. Easton, West Oakland, Cal.		
B. F. Ferris, Los Angeles, Cal.		
J. F. Fisher, Sacramento, Cal.		
M. Fisher, Ogden, Utah.		
A. Fraser, Bakersfield, Cal.		
Neil Fraser, Mayfield, Cal.		
P. Fritz, Los Angeles, Cal.		
W. Gaskin, Los Angeles, Cal.		
Ira Gentis, Oakland, Cal.		
P. Giusto, San Francisco, Cal.		
J. A. Given, Sacramento, Cal.		
Jas. Gratto, Los Angeles, Cal.		
C. F. Green, Sacramento, Cal.		
H. A. Hampton, Portland, Ore.		
Robt. Hansen, West Oakland, Cal.		
W. C. Harman, Bakersfield, Cal.		
J. M. Hinchee, Los Angeles, Cal.		
J. A. Hutchens, Ogden, Utah.		
Jno. D. Isaacs, New York City.		
C. A. Jensen, Los Angeles, Cal.		
H. Lodge, San Francisco, Cal.		
C. W. McCandless, Ventura, Cal.		
W. H. McCoy, Dunsmuir, Cal.		
D. McGee, Sacramento, Cal.		
A. M. McLeod, Oakland, Cal.		
J. B. Malloy, San Francisco, Cal.		
J. D. Mathews, Tucson, Ariz.		
F. D. Mattos, W. Oakland, Cal.		
M. J. Mayer, San Francisco, Cal.		
A. T. Mercier, Los Angeles, Cal.		
E. C. Morrison, San Francisco, Cal.		
J. J. Murphy, Oakland, Cal.		
P. N. Nelson, San Francisco, Cal.		
Harry Pollard, San Francisco, Cal.		
Homer Pollard, West Oakland, Cal.		
Geo. W. Rear, San Francisco, Cal.		
J. S. Replogle, Oakland, Cal.		
D. B. Rich, Stockton, Cal.		
D. T. Rintoul, Bakersfield, Cal.		
A. L. Robinson, Stockton, Cal.		
Norman Rose, Portland, Ore.		
W. M. Rose, Sacramento, Cal.		
Niles Searls, San Francisco, Cal.		
Fred Secord, Sacramento, Cal.		
G. W. Sedwell, Bakersfield, Cal.		
C. W. Smith, Portland, Ore.		
Thos. Tretheway, Stockton, Cal.		
E. J. Vincent, Los Angeles, Cal.		
A. Weldon, Bakersfield, Cal.		
C. A. Wester, Dunsmuir, Cal.		
M. M. Wilson, Los Angeles, Cal.		
South Manchuria Ry.,	1	10,000
Y. Maruyama, Dairen, Japan.		

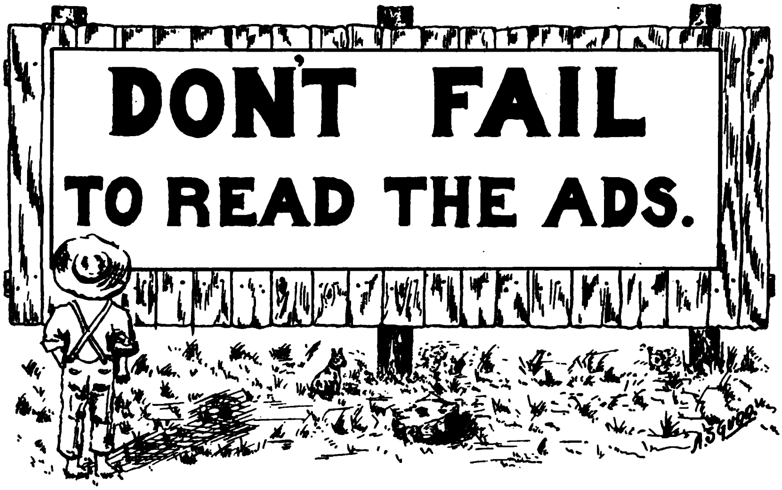
Name of Road and Membership.	Members.	Mileage.
Tennessee Central R. R. E. M. Carter, Nashville, Tenn.	1	293
Texas & Pacific Ry. E. Loughery, Marshall, Tex.	1	1,944
Texas Midland R. R. **E. H. R. Green, Terrell, Tex.**	1	**125**
The Thousand Islands Ry. H. A. Cooper, Gananoque, Ont.	1	18
Toledo, Peoria & Western Ry. **J. H. Markley, Peoria, Ill.**	1	**248**
Toledo Railways & Light Co., A. Swartz, Toledo, O.	1	110
Trinity & Brazos Valley Ry. B. M. Hudson, Teague, Tex.	1	466
Union Pacific System **J. Parks, Denver, Colo.**	1	7,825
Virginian Ry. P. W. Cahill, Roanoke, Va.	1	503
Wabash R. R. A. O. Cunningham, St. Louis, Mo. E. C. Danes, Peru, Ind. William S. Danes, Peru, Ind.	3	2,519
Washington Terminal Co., **W. M. Cardwell, Washington, D. C.**	1	53
Western & Atlantic R. R. D. E. Counts, Dalton, Ga.	1	137
Western Australia Government Rys. E. S. Hume, Midland Jct., Western Australia.	1	1,943
Western Pacific Ry. M. R. Krutsinger, Sacramento, Cal. T. J. Stuart, Elko, Nev.	2	946
Wheeling & Lake Erie R. R. Wm. Mahan, Canton, O. W. L. Rohbock, Cleveland, O. E. U. Smith, Cleveland, O.	3	459
Yazoo & Miss. Valley R. R. D. H. Holdridge, Vicksburg, Miss. W. Shropshire, Greenville, Miss.	2	1,370

No. of Railroads Represented,	124	
Total, Members and Mileage,	595	267,421
Members not with Railroads,	68	
Total Membership,	663	

INDEX TO ADVERTISEMENTS

American Hoist & Derrick Co., ... 394
American Valve & Meter Co., ... 401
Asphalt Ready Roofing Co., ... 422
Associated Manufacturers Co., ... 408-416
Barker Mail Crane Co., ... 427
Barrett Manufacturing Co., ... 390
Bates & Rogers Construction Co., ... 419
Bird & Son, ... 392
Brown, Harold P., ... 418
Caldwell & Son Co., H. W., ... 393
Cement World, ... 431
Cheesman & Elliot (National Paint Works), ... 428
Chicago & Northwestern Railway, ... 391
Chicago Bridge & Iron Works, ... 410
Chicago, Milwaukee & St. Paul Ry., ... 405
Chicago Pneumatic Tool Co., ... 426
Clapp Fire Resisting Paint Co., ... 420
Cleary White Construction Co., ... 417
Columbian Mail Crane Co., ... 429
Concrete Mixing & Placing Co., ... 425
Cortright Metal Roofing Co., ... 421
Dickinson, Paul, Inc., ... 425
Dixon Crucible Co., ... 398
Engineering and Contracting, ... 431
Engineering News, ... 429
Fairbanks, Morse & Co., ... 396
Flintkote Mfg. Co., ... 399
Gifford-Wood Co., ... Colored Insert
Golden-Anderson Valve Specialty Co., ... 403
Great Lakes Dredge & Dock Co., ... 424
Hayward Co., The, ... 420
Heyworth, Jas. O., ... 426
Hunt, Robt. W. Co., ... 419
Illinois Central R. R., ... 407
Industrial Works, ... 411
Johns-Manville Co., H. W., ... 412
Johnson & Jennings Co., ... 430
Kelly-Derby Co., ... 421
Leyden-Ortseifen Co., ... 431
Massey, C. F. Co., ... 400

Mechanical Manufacturing Co., ...395
Missouri Valley Bridge & Iron Co., ...429
National Blue Print Co., ...428
National Roofing Co., ...413
Nichols, Geo. P. & Bro., ...428
Ogle Construction Co., ...427
Railway Age Gazette, ...423
Railway Review, ...431
Revere Rubber Co., ...424
Ryerson & Son, Jos. T., ...418
Snow, T. W. Const. Co., ...404
Snow, T. W. Const. Co. (Dawson Balanced Valve Co.), ...422
Southern Pacific Co., ...409
Standard Asphalt & Rubber Co., ...397
Statler Hotels, ...406
Strobel Steel Construction Co., ...428
Toch Bros., ...Inside Front Cover Page
Union Fibre Co., ...417
Universal Oil Gas Generator Co., ...414
Volkhardt Co., Inc., ...415
Warren Chemical & Mfg. Co., ...Back Cover Page
Webb, F. W. Mfg. Co., ...402
Williams, White & Co., ...423
Wisconsin Bridge & Iron Co., ...Inside Back Cover Page



A severe roofing test—

Maine Central Roundhouse, Waterville, Maine. Plans drawn by Engineering Department of the Maine Central Railroad at Portland, Maine.

General Contractors: Horace Purinton & Co., Waterville, Me.

Roofer: Wallace A. Hill, Fairfield, Maine.

The roof of a railroad roundhouse *must be a good roof*—otherwise its life is short.

Not only must it withstand the ordinary weather hazards but in addition must resist the sulphurous gases of coal smoke, the flying sparks, the intense heat from the locomotives and the condensation of moisture from the steam exhausts. It must resist all these attacks from both above and below.

The ideal roof for such buildings is a Barrett Specification Roof. That railroad engineers recognize this is evidenced by the fact that such roofs cover a very large proportion of the roundhouses of the country. It is under severe conditions that Barrett Specification Roofs show to the best advantage.

Barrett Specification Roofs also cover most of the first class buildings of the country, including manufacturing plants of all sizes, the big city skyscrapers, railroad buildings, steamship piers, apartment houses, etc.

Every building worthy of the name "permanent" should carry a Barrett Specification Roof because the owner will get longer service at less cost than by using any other kind.

These roofs take the base rate of insurance and are approved by the Underwriters' Laboratories. We should like to send every architect, engineer and building owner a copy of the Underwriters' Laboratories report on Barrett Specification Roofs. Address nearest office.

Special Note We advise incorporating in plans the full wording of The Barrett Specification, in order to avoid any misunderstanding. If any abbreviated form is desired, however, the following is suggested: ROOFING—Shall be a Barrett Specification Roof laid as directed in printed Specification, revised August 15, 1911, using the materials specified and subject to the inspection requirement.

A copy of The Barrett Specification, with roofing diagrams, free on request.

BARRETT MANUFACTURING COMPANY

New York. Chicago Philadelphia Boston St. Louis Cleveland Cincinnati Pittsburgh
Detroit Birmingham Kansas City Minneapolis Salt Lake City Seattle Peoria
THE PATERSON MFG. CO., Limited: Montreal Toronto Winnipeg Vancouver
St. John, N. B. Halifax, N. S. Sydney, N. S.

TRADE B MARK

The famous, heavily rock ballasted, double tracked, automatic safety signal line between Chicago and the Missouri River. The Pioneer Line West and Northwest of Chicago.

Over 10,000 Miles

of Perfectly Equipped Railway

is included in the wonderful system of the **Chicago & North Western Line.** It is the direct route and provides unequaled train service from Chicago to

Ashland
Boone
Cedar Rapids
Clinton
Council Bluffs
Des Moines
Duluth
Eau Claire
Fond du Lac
Green Bay
Huron
La Crosse
Madison
Mankato
Marquette
Marshalltown
Mason City
Milwaukee
Minneapolis
Oakes
Omaha
Oshkosh
Pierre
Rochester
St. Paul
Sioux City
Superior
Winona

the Black Hills and other important points in Illinois, Wisconsin, Northern Michigan, Minnesota, Iowa, Nebraska, Wyoming, the Dakotas, Colorado, Utah, California and the North Pacific Coast.

The Best of Everything

Chicago & North Western Ry.

A. C. Johnson, P. T. M. C. A. Cairns, G. P. & T. A.
Chicago, Ill.

NW3992

One Roofing Used Twice

After fighting smoke, burning cinders and storm for seven years, the roofing shown above on the old Wells Street Station of the C. & N. W. R. R. in Chicago, was rolled up and used to re-roof several suburban stations. It is

NEPONSET PAROID ROOFING

This hard wear has not taken the life out of the roofing, and it is now giving perfect service in its new locations. A good life insurance risk is the man who lives beyond the average time—longer than he is *expected* to live. A good roofing is one that lasts *longer* than is necessary. That's what NEPONSET Paroid does. An ideal roofing for factories, storehouses and farm buildings.

BIRD & SON **515 Neponset Street**
E. Walpole, Mass.
New York Chicago Washington San Francisco
Canadian Plant: Hamilton, Ont.
Established 1795

NEPONSET
Proslate Roofing
makes a handsome red or green roof for houses

ICE HANDLING AND HARVESTING MACHINERY

CARTS CRUSHERS TROLLEY SYSTEMS

ENDLESS CHAIN CONVEYORS. ELEVATORS

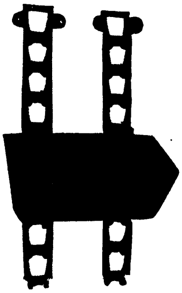
Complete Equipment for icing and re-icing refrigerated traffic with least possible delay
Send for Special Ice Machinery Catalogs

ELEVATING, CONVEYING *and* POWER TRANSMITTING MACHINERY

Caldwell "HELICOID" Conveyor

Ask for Catalog
38

- Screw Conveyors
- Belt Conveyors
- Steel Elevator Legs
- Elevator Buckets
- Gears with Cut or Machine Molded Teeth
- Chain Belting
- Sprocket Wheels
- Shafting, Bearings



Send Us Your
Inquiries

H. W. CALDWELL & SON CO.

17th St. and Western Ave., Chicago
HUDSON TERMINAL, 50 CHURCH ST., NEW YORK

The Farther You Are from Repair Facilities, the more reason there is for using "AMERICAN" Machinery

---

¶ Dependable equipment is the *big thing* in construction work remote from convenient repair facilities.

Your Engines
Derricks
Wire Rope Clips
Blocks and Sheaves

must not only have the strength to do your work, but must be dependable. A repair part may not cost much in itself, but if it ties up your operation ten days while you wait for it the cost begins to look pretty big

"AMERICAN" Machinery

is dependable. The farther you get from repair facilities the stronger the truth of this statement will be brought home to you.

American Hoist & Derrick Company

St. Paul, Minn.

H.761

THE ELLIS Patent Bumping Posts

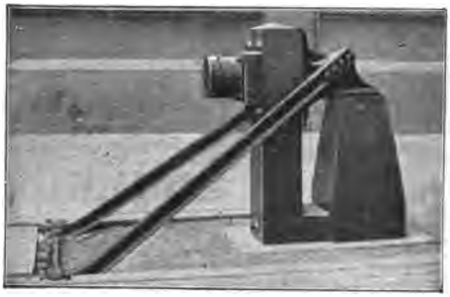
Noted for simplicity strength and lasting qualities. Neat in appearance. Occupy little space. Adapted to all positions. Highest Award at the World's Fair.

Shipped Complete With Directions for Erection

Write for circulars and prices.

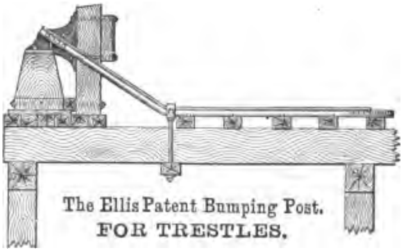
Mechanical Mfg. Co.

Chicago, Ill.



Standard Passenger Post

Standard Freight Post



The Ellis Patent Bumping Post.
FOR TRESTLES.

A Test

A Money Saving
Pumping Unit
For Railway Service

Type "Y"
Oil Engine
and Double Acting Power Pump
self contained on one base

Operates on LOW GRADE Oils
supplying cheap power

Has long life -- low upkeep

Fairbanks, Morse & Co.
St. Louis Chicago Saint Paul

467-23L

MINERAL RUBBER FLOORS

Cab Stand M. C. R. R. Station, Detroit, Mich.
SARCO Mineral Rubber Floor

Sarco No. 6 Waterproofing
Mineral Rubber Floors
" Refrigerator Compound
" Damp Proofing
" M. R. Pipe Coating
" Electric Insulations
" R. S. A. Specifications
" Roofing Materials
" Asphaltum Coatings
" Expansion Joint Compounds

Fillers

Road Materials

Putty

Paint

Standard Asphalt & Rubber Co.

208 So. LaSalle Street CHICAGO, ILL.

Bridge, New York, New Haven & Hartford Railroad, Readville, Mass.

THIS is one of the many prominent exhibits which bear testimony to the durability of

DIXON'S

SILICA GRAPHITE PAINT

It was painted eleven years ago with this ***"Longest Service"*** paint and is still secured against rust-producing agents, whether moisture, gases, brine drippings, heat or cold, etc.

Railroad economists and engineers specify Dixon's Silica-Graphite Paint because it shows the lowest yearly cost, when you divide the many years of service into the ***First Cost.*** Made for fifty years in ***First Quality*** only.

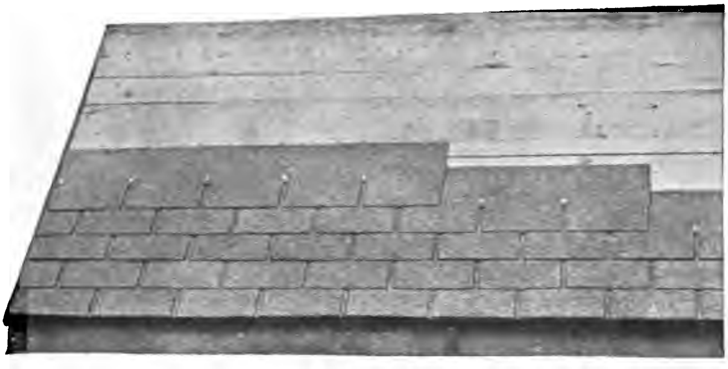
The only paint which contains nature's mixture of the silica and flake graphite. Mined alone by the Dixon Company.

Write for list of prominent railroad bridges in the United States, India Central and South America, etc., painted with Silica-Graphite Paint

Made in Jersey City, N. J., by the

Joseph Dixon Crucible Co.

Established 1827



Rex Strip Shingles

RED— SLATE SURFACED — GREEN

Five Shingles Handled at a time

1-2 the nails
1-2 the nail holes
1-2 less labor
1-5 the cracks
No chalk line
No spacing

The bigger the job the more money they save

FLINTKOTE MFG. COMPANY, ***Inc.***

MAIN OFFICE: 88 PEARL STREET, BOSTON, MASS.

New York **66 Beaver St.**	**Chicago** **655 Peoples Gas Bldg.**	**New Orleans** **705 Hennen Bldg.**

Manufacturers of the Famous Rex Flintkote Roofing

C. F. Massey Company

NEW YORK CHICAGO SPOKANE

REINFORCED CONCRETE PRODUCTS

Manufacturers of

Reinforced Concrete Piles
Reinforced Concrete Bridge Slabs
Culvert and Sewer Pipe
Battery Wells and Chutes
Portable Concrete Houses

PLANTS located at

NEWARK, N. J.
CHICAGO, ILL.
MINNEAPOLIS, MINN.
DES MOINES, IA.
ANNA, ILL.
SPOKANE, WASH.
MEMPHIS, TENN.

Gifford-Wood Co.'s

SUPERIOR QUALITY

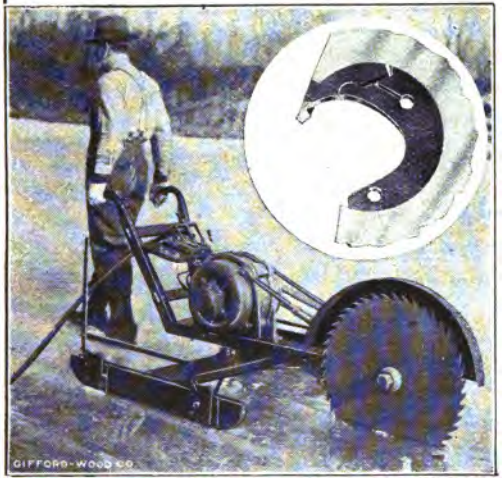
ICE TOOLS

INCLUDING

Planers, Scrapers, Plows, Markers, Bars, Chisels, Hooks, Tongs, Shavers, Saws, Axes, Picks and Ice Crushers

LIGHT and Easy to Handle **POWER FIELD SAW** **Practically Self Propelling**

Patented by L. M. Macy, Adel, Iowa



WEIGHT 600 POUNDS

Much more economical than horses, better ice, larger daily runs, perfectly balanced, can be used on any ice field.

One Extra Inserted Tooth Saw and 500 feet of Special Flexible Cable furnished with each outfit

Ask for Bulletin No. 20

ICE
Elevators
Conveyors

CHICAGO OFFICE

565 W. Washington St.
One block west of the N. W. R. R. Depot

GIFFORD-WOOD CO.

Main Office and Works
HUDSON, N. Y.

(OVER)

New York, 30 Church St.
Boston, 51 No. Market St.

ICING STATION MACHINERY

Icing Station with Salt Elevator

G—W

Car Icing Equipments

are in use by all leading Packers and Railroads. Some of the users include--

N. Y. C. & H. R. R.
Union Pacific
C. M. & St. P.
I. I. & I.
C. & N. W.
Erie
D. L. & W.
B. & O.
So. Pacific
D. & H.
L. V.
C. N. E.
Nat'l Pkg. Co.
Armour & Co.
Swift Co.
Morris & Co.
Cudahy & Co.
Mexican Nat'l Pkg. Co.
Hammond & Co.
Pacific Fruit Express
Fruit Growers Express
Chi. Ind. & So.
Santa Fe
O. S. Line
B. & A.
C. R. I. & P.
Cen. of N. J.
N. Y. O. & W.
N. Y. N. H. & H.
Ill. Central
Mo. Pacific
C. B. & Q.

WE DESIGN, MANUFACTURE AND INSTALL READY FOR USE

Ice Elevators—Conveyors—Lowering Machines—Platform Conveyors Salt Elevators
Ice Crushers—Crushed Ice Elevators and Carts

BASIN SAW OUTFITS

Engineering Services Free Write for Catalog

GIFFORD-WOOD CO.

565 W. Washington St. (OVER)

Main Office and Works
Hudson, N. Y.

Chicago, Ill.

Boston, Mass.
New York City

THE SUCCESSFUL

Poage Water Column

With FENNER DROP SPOUT

The Reasons Why:

❡ The Flexible Fenner Drop Spout has a **FIVE FOOT VERTICAL** and **THREE FOOT LATERAL** movement. It also can be pulled out or in—longer or shorter than normal length. This flexibility prevents water waste. It saves a great amount of time in taking water, as accurate spotting of the locomotive is unnecessary. It acts as a big maintenance saver in that the spout will move should the locomotive shift. Many water columns with more rigid spouts are knocked down because of the shifting of the locomotive while taking water.

❡ **THE SPOUT IS ABSOLUTELY NON-FREEZABLE.** There is no packing or working parts in the joint. It is **OPEN TELESCOPIC.**

❡ The water is **AUTOMATICALLY** shut off and the spout when released returns parallel to the track by gravity.

❡ The entire mechanism is very simple and the few parts that compose it are built with an extra margin of strength.

❡ Write for the booklet with complete information **TODAY.**

MANUFACTURED BY

THE AMERICAN VALVE & METER CO.

CINCINNATI, U. S. A.

The
"B. & M. Special"

Water Closet Combination

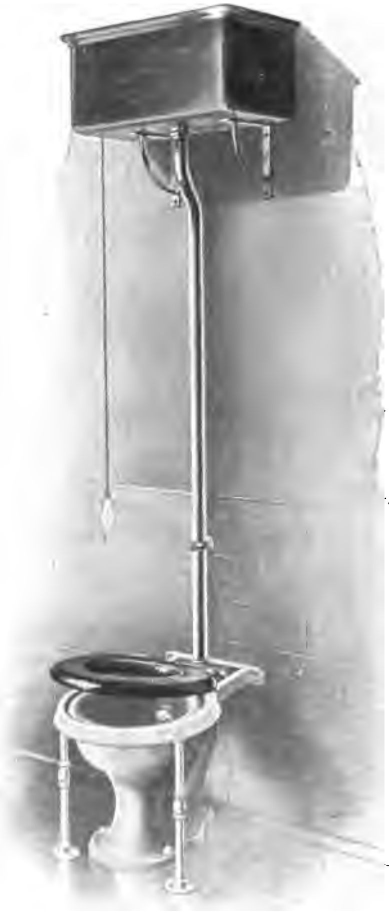


Illustration shows the essential parts of this eminently practical and durable outfit. The earthen closet is of extra thickness and is protected by a malleable iron frame, to which seat is attached by our special extra heavy brass hanger.

Closet can be furnished to operate by Seat Action instead of Pull and Chain if desired.

This combination has been adopted on the Boston & Maine and Maine Central Railroad Systems, for use in stations, shops, etc.

We are manufacturers and wholesale dealers in Plumbing, Steam and Gas Supplies; we make a specialty of Railroad and Steamship work.

Write for descriptive Circular of the B. & M. Closet Combination. and for our general catalogues.

F. W. Webb
Mfg. Company
BOSTON

The Controlling Altitude Valves

CONNECTION TO DELIVERY SIDE
ADJUSTMENT FOR HIGH & LOW PRESSURE
GOLDEN-ANDERSON V.S. CO
CONTROLLING ALTITUDE VALVE
PITTSBURG, PA.
INLET

"Increase the Efficiency of Railroad Water Service"

No Floats, No Valves Inside of Tanks

Automatically maintain a uniform stage of water in Standpipes, Reservoirs or Tanks. No overflow in case of fire pressure. Valves closed by water or electricity.

Float Valves *Standpipe Valves*
Electro-Hydraulic Valves

Automatic Valves

For Steam and Water Service

"Automatic Float Valves"

"Angle or Globe"

Valves to 24 inch

The Golden-Anderson Automatic Float Valves

are instantly adjusted to operate Quickly or Slowly as desired. Indestructible. They are Absolutely the Only Satisfactory Float Valves Known for High or Low Pressure.

Valves up to 24 inches

Automatic Cushioned Water Pressure Regulating Valves

We make the largest, heaviest and most correct mechanically constructed and operated line of Automatic Valves for high or low pressure steam and water service in the U. S.

Water Pressure Regulating
Valves to 24 inch

Golden-Anderson Valve Specialty Co.

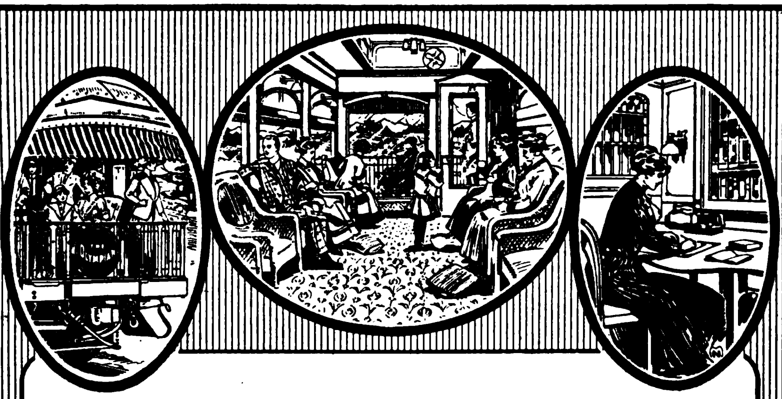
1207 Fulton Bldg. Pittsburgh, Pa.

SNOW
WATER
CRANE
WITH
TELESCOPIC SPOUT

OIL ENGINES

HEAVY
DUTY
SEMI-DIESEL

T. W. SNOW CONSTRUCTION CO.
CHICAGO



Travel in Luxurious Ease
on *"The Olympian"*
Chicago to the Pacific North Coast

The observation cars on this splendid train are masterpieces of the car builder's art — the embodiment of every known travel luxury and comfort.

They have commodious observation lounging room and roomy platform—writing room and library—buffet smoking room—barber shop and bath—Afternoon tea is served in lounging room, daily without charge — Telegraphic news bulletin and telephone service is provided en route.

"The Olympian" **leaves Chicago daily at 10:15 p. m., arrives Seattle 8:00 p. m., Tacoma 9:30 p. m. third day.** ***"The Columbian,"*** **companion train of** ***"The Olympian,"*** **leaves Chicago 8:30 a. m. daily—the route is over the scenic**

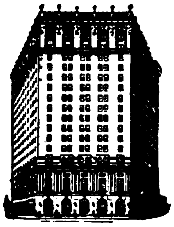
CHICAGO
Milwaukee & St. Paul
RAILWAY

"The Trail of The Olympian," a beautiful 40-page pictorial book, can be secured free from any agent or representative of this company or by addressing

GEO. B. HAYNES, *General Passenger Agent,* CHICAGO

Hotels Statler

BUFFALO
450 Rooms 450 Baths
Rates from $1.50 a day



DETROIT
800 Rooms 800 Baths
Rates from $1.50 a day
200-room addition building

CLEVELAND
700 Rooms 700 Baths
Rates from $2.00 a day
300-room addition building

To You Men Who Travel on Business

HOTEL accommodations ought to be bought like merchandise on a full-value basis. You ought to want, and get, your money's worth.

Hotels Statler specialize in the very sort of hotel accommodations the business man wants to buy. We do not merely rent you a room -- we sell you *a service of comfort and convenience.*

We furnish you a *good* bed, in a clean, light, well-ventilated, pleasant room; a luxurious bath and shave in your own private bath-room. You don't have to ask for ice-water — a circulating system brings it to you; you don't have to ask for stationery—it's in your writing desk; you don't have to ask for a morning paper — it's left under your door before you wake (and there's no charge). Such things as these are but the starting point of the complete, interested service you get at Hotels Statler —where "the guest is always right." *And you get them whether you pay $1.50 or $6 for your room.*

You get more for your money — unquestionably — at a Hotel Statler. Ask anyone who has ever stopped with us.

New Orleans

Song Birds and Flowers

the whole winter through, coupled with a genial semi-tropical climate, are features in the popularity New Orleans enjoys as a winter resort, although they are but incidental to its many allurements to both the casual and the long-term visitor. It has its old French and Spanish sections, teeming with reflections of

A Past Foreign Epoch

of much grandeur. Quaint little shops having wares with an individuality, fascinating architectural types that hold one's attention, and at every turn examples or evidences of manners and customs peculiar to the section. It also has its modern section, in which are portrayed the prosperity and

Beauties of the Modern Days

in its palatial homes mid settings of semi-tropical foliage and flowers, its parks and its public institutions. Then there is its business section, with its alluring stores in which wares can be purchased not to be found elsewhere in the country; also its mercantile establishments, and the external evidences of its mighty river traffic. Again, there are its famous restaurants and its noted hotels, and, finally, there is its

Famous Carnival Season including the World-Famous Mardi-Gras

New Orleans is also the gateway to the West Indies, Panama and Central America, with adequate regular steamship service thereto, and during the present season via United Fruit Co.'s steamers to Cuba, Jamaica, Costa Rica and Panama.

Send for booklet "New Orleans the Convention City" and take the

Illinois Central

"Panama Limited" (Steel Train) or "New Orleans Special" from Chicago to New Orleans, leaving Chicago at 6: 35 p. m. and 9: 10 a. m., respectively.

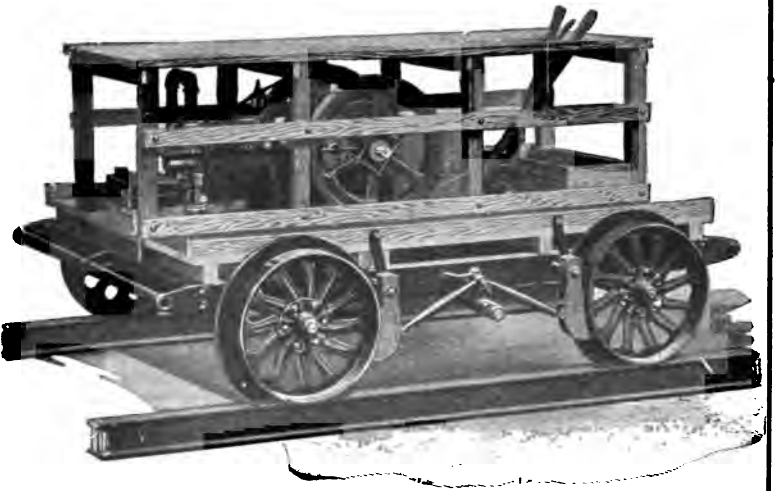
H. J. Phelps,
General Passenger Agent,
Chicago, Ill.

G. H. Bower,
General Passenger Agent,
Memphis, Tenn.

S. G. Hatch,
Passenger Traffic Manager.

HUSKY JERRY BOY MOTOR CARS

2 1-4 and 4 H. P.



MEAN

QUICK transportation of men and material.

SAVING of energy for direct track work.

LOW FIRST cost—small Maintenance expense.

POWERFUL four-cycle reversible engine.

ABSOLUTE reliability at all times.

Another big order for Engines from one of the large railroad systems certainly indicates that Jerry Boy is making good. The splendid service record back of this Engine challenges the most careful investigation.

ASSOCIATED MANUFACTURERS CO.

WATERLOO, IOWA

SOUTHERN PACIFIC
SUNSET
OGDEN & SHASTA
ROUTES

FIRST IN SAFETY

Four Gateways
TO THE
Pacific Coast

NEW ORLEANS--OGDEN—PORTLAND-EL PASO

"Sunset Route"

Two Daily Trains from New Orleans via Houston, San Antonio, El Paso and Tucson to Los Angeles, thence to San Francisco via the Coast Line or San Joaquin Valley Line.

The "Sunset Route" extends from New York to New Orleans by Southern Pacific's splendid Atlantic Steamers, sailing Wednesdays and Saturdays.

"Ogden Route"

Four Daily Trains from Chicago via Omaha, or via St. Louis, Kansas City and Denver, through Ogden, over the Great Salt Lake Cut-Off, and crossing Nevada and California to San Francisco.

"Shasta Route"

Four Daily Trains from Seattle, Tacoma and Portland to San Francisco, connecting with through trains from Chicago, St. Paul, Minneapolis and Montreal, traversing the Great Pacific Northwest.

"El Paso Route"

Two Daily Trains from Chicago and St. Louis via Kansas City, El Paso and Tuscon to Los Angeles and San Francisco.

Southern Pacific Service is the Standard

Best Dining Car in America

Oil Burning Engines—No Cinders, No Smudge, No Annoying Smoke

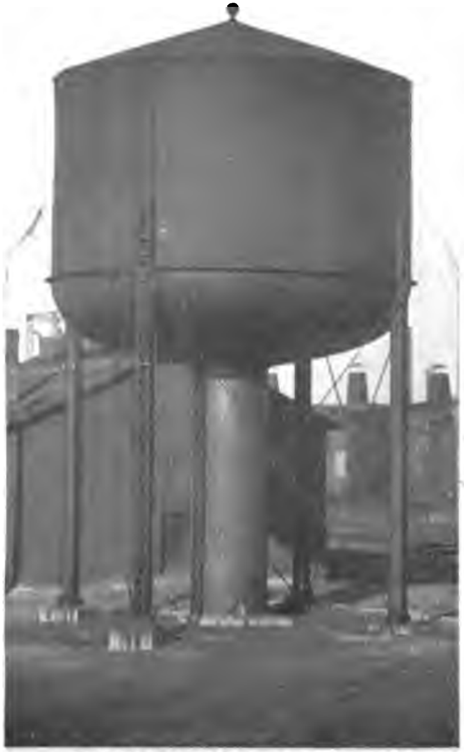
Awarded Grand Prize for Railway Track, Equipment, Motive Power and Safety-First Appliances, San Francisco Exposition 1915

For Fares and Further Particulars, Address

W. G. Neimyer, General Agent
55 West Jackson Boulevard, Chicago, Ill.

L. H. Nutting, General Eastern Passenger Agent
366 Broadway, New York, N. Y.

Chas. S. Fee, Passenger Traffic Manager, San Francisco, Calif.



Standard Elliptical Bottom Railroad Tank

Chicago, Burlington & Quincy R. R. Co., Ottumwa, Iowa
Capacity, 100,000 gallons. Height, 20 feet to bottom

CHICAGO BRIDGE & IRON WORKS

We specialize in Building

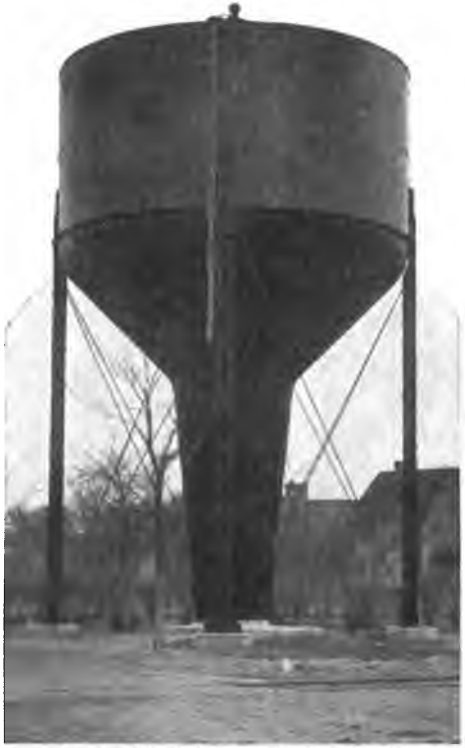
Steel Water Tanks for Railway Service

With fabricating plants located at Greenville. (Pittsburgh District) Pennsylvania, Chicago, Illinois, and Bridgeburg, Ontario, we are in a position to quote attractive prices for work to be erected at any location. Write to our nearest sales office for plans, specifications and estimates on your requirements.

See report and discussion on Railway Water Tanks on page 129 of this issue.

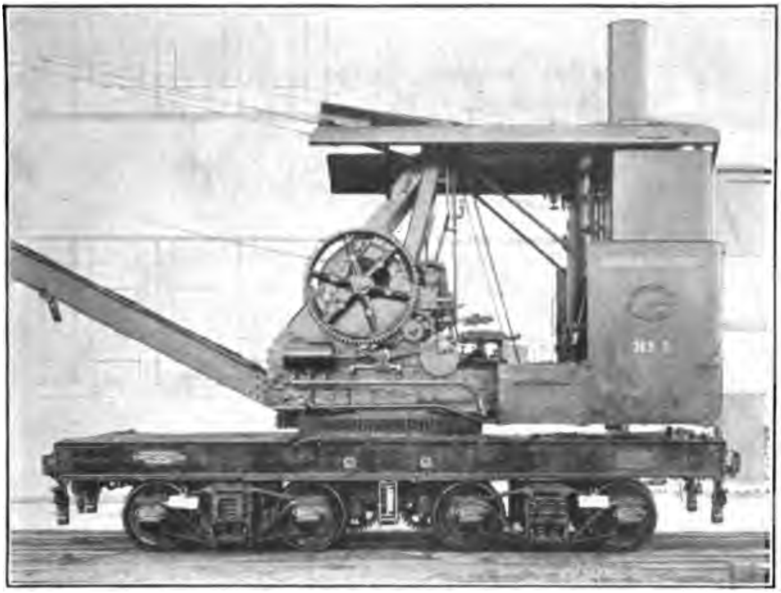
Sales Offices

Chicago, Illinois	**Old Colony Bldg.**
New York, N. Y.	**30 Church Street**
Dallas, Texas	**Praetorian Bldg.**
Greenville, Pa.	**110 York Street**
Bridgeburg, Ont.	**112 Janet Street**
Charlotte, N. C.	**Realty Bldg.**
Monticello, Fla.	**Box 367**



Standard Conical Bottom Railroad Tank

Chicago & Northwestern Ry. Co., Ames, Iowa
Capacity, 100,000 gallons. Height, 20 feet to bottom



An Unconscious Recommendation

OF

INDUSTRIAL WORKS LOCOMOTIVE CRANES

THE committee on locomotive cranes recommended certain features (see page 47) as essential to make a crane most useful and efficient. Present day

Industrial Works Locomotive Cranes

INCLUDE EVERY ONE OF THESE FEATURES AS STANDARD PRACTICE except a radius indicator

(Such an indicator will be supplied if desired, but unless loads of known weight are being handled, its value is questionable and we have not favored its general use.)

We feel that the unconscious recommendation of our cranes by a committee using various makes proves the assertion that Industrial Works Cranes are built by practical men who know what railroad service actually demands of a crane.

Pioneering is expensive but it leads to a quality product.

INDUSTRIAL WORKS, Bay City, Michigan

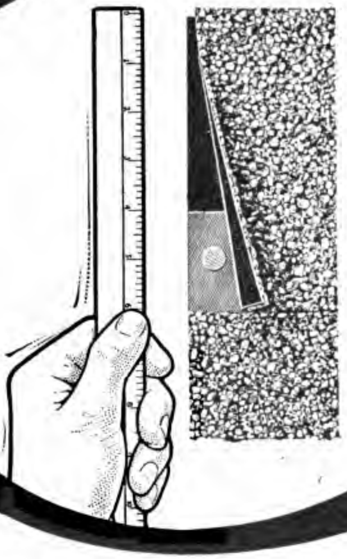
Each product listed has stood the severest tests of America's Railroads

J-M Asbestos Roofings and Asbestoside
J-M Corrugated Asbestos Roofing
J-M Transite Asbestos Wood Smoke Jacks
J-M Waterproofing Materials
J-M Mastic Flooring
J-M Pipe Insulation
J-M Sanitary Plumbing Specialties
J-M High Temperature Cements
J-M Vitribestos Materials
J-M 85% Magnesia and Asbestos Fire Felt Locomotive Lagging
J-M Air Brake Cylinder Packing Expander Ring
J-M Manual Slack Take Up for Air Brake Systems
J-M Packings and Gaskets
J-M Hose-Flexible Metallic, Steam, Air, Water, Suction, Fire, etc.
J-M Locomotive Squirt Hose
J-M Metallic Sand Spout
J-M Line Materials
J-M Electrical Supplies
J-M Fire Extinguisher
J-M Asbestos Sill Covering
J-M Cold Storage Insulation
J-M Hair Felt
J-M Fibre Conduit
J-M Sectional Conduit

JOHNS-MANVILLE SERVICE
COVERS THE CONTINENT

H.W. Johns-Manville Co.
New York and all large cities

SIX INCHES
of ASPHALT
CEMENT-WELDED JOINT



Instead of the ordinary, clumsy joint, easily broken and with all nail-heads showing, you can have an absolutely tight, six-inch weld, without a nail-hole through the roof, if you use

SECURITY
WIDE-WELD
ASPHALT
ROOFING

Write today for free book, "The Requirements of a GOOD Roof." It tells in detail why Security Wide-Weld Asphalt Roofing meets these requirements, and how easy it is to weld the patented 6-inch joint.

The National Roofing Co.
Manufacturers of Asphalt Roofing and Paint
Address communications to 217 Filmore Ave. Tonawanda, N.Y.

Generator on C. & N. W. 10 H. P. Otto Engine at Clearwater, Neb.

Convert your Gasoline Engines into OIL BURNERS using

Kerosene or Power Distillate

Save 50% or better over the present cost of operation

A 30 Day Trial will convince you

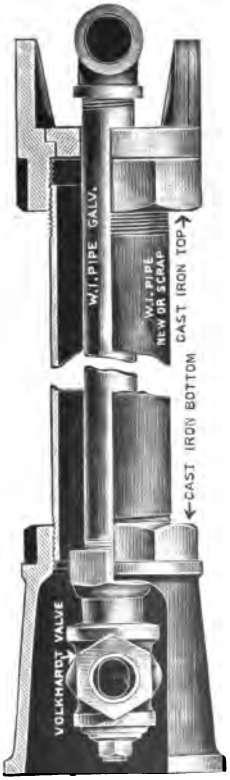
No expense to you unless successful. Standard with the Standard Oil Co. and many of the railroads

Universal Oil Gas Generator Co.

2414 W. 20th St. CHICAGO, ILL.

THE VERY NEWEST *in*
HYDRANTS

WE will show you how to build this strong, durable, "can't freeze" hydrant, partly out of scrap steam pipe, the best idea ever. Ask and ye shall be made wise.



CAST IRONTOP WITH "STOP" LUGS

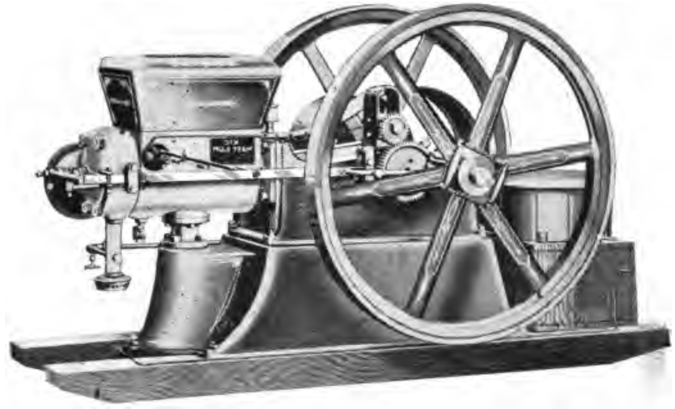
HERE is a long sought opportunity. Get 25 sets of the cast iron tops and bottoms and use up your scrap steam pipe for an outer casing, working at odd times. Make length to suit conditions on your division and be ready to meet emergencies by having 6 Volkhardt cocks on hand. Galvanized pipe and fittings you always have. Build the strongest "can't freeze" hydrant ever planned for railroad service. For further details write

Volkhardt Company, Inc.
51 Townsend Ave.
Stapleton, N. Y.

W. C. SQUIRE & CO., Western Agents, Western Union Bldg., Chicago, Ill.

POWER *for*

Hoisting, Pumping, Sawing



¶ The Associated Line of Gasoline Engines provides absolutely reliable power -- just the kind you need in your construction work.

¶ These Engines bearing all the latest improvements in design and construction are the only ones meeting the most rigid requirements.

SEND FOR CATALOGUE

ASSOCIATED MANUFACTURERS CO.

WATERLOO, IOWA

CLEARY WHITE
CONSTRUCTION CO.
105 West Monroe Street
CHICAGO

General Contractors

Concrete and foundation work of every description.
All classes of Railroad Construction.

LINOFELT - FIBROFELT - LITH-MINERAL WOOL

Insulation for Railway Structures

Consider the great economies gained *at low first cost* by using our insulation for:

Station Buildings and Offices (effecting 1-3 reduction in fuel bills)
Ice Houses and Pre Cooling Plants
Ice Boxes for Station Dining Rooms and Kitchens
Round House Roofs to prevent condensation
Frost Boxes on Water Tanks. Brine and Cold Water Pipes

Railway Exchange
Chicago, Ill.

UNION FIBRE COMPANY
Winona, Minnesota

Wainwright Building
St. Louis, Mo.

Samples and Information on Application

Ryerson Friction Saw

For Railroad Use

THIS saw has long been known as the most efficient and rapid machine on the market for the cutting of rails, beams, angles, channels, tees, zees, round bars, etc., as well as the various special sections which are now being employed in steel coach construction.

WE will be pleased to send you railroad bulletin 9071 giving specifications and details.

ESTABLISHED 1842 INCORPORATED 1888

JOSEPH T. RYERSON & SON

CLYDE M. CARR, PRESIDENT JOSEPH T. RYERSON, VICE-PRES.

IRON STEEL MACHINERY

CHICAGO

Tunnels Lined With Concrete

Without Forms.

Retaining Walls and Culverts Repaired with Waterproof Concrete. Wooden structures fireproofed with thin covering of STEAM-JETTED CONCRETE.

The Concrete Atomizer

needs no air compressor.

Refer to concrete work on Delaware, Lackawanna & Western Railroad, Chicago Great Western Railroad, and others.

HAROLD P. BROWN,

121 Cedar St. New York.

Robert W. Hunt Jno. J. Cone Jas. C. Hallsted D. W. McNaugher

Robert W. Hunt & Co.

ENGINEERS

Inspectors of Machinery, Structural and Reinforcing Steel
For Bridges, Buildings and Other Structures,
Tests and Inspection of Cement and Rails,
Creosoted Blocks, Timbers and Ties,
Inspectors Permanently Located at Steel Mills
And Manufacturing Plants,
Supervision of Building Construction.

General Offices: CHICAGO

New York Pittsburgh St. Louis San Francisco
Cincinnati Dallas Los Angeles Seattle
Montreal Vancouver

BATES & ROGERS
CONSTRUCTION CO.

875 Old Colony Building
Chicago

206 Lindelle Block
Spokane, Wash.

Civil Engineers
and
General Contractors

Concrete and Foundation Work, Tunnel Lining, Dams, Hydro-electric Power Developments, and all classes of Railroad Construction

An Indispensable Aid to the Bridge Builder

HAYWARD ORANGE PEEL BUCKETS

for digging from within cofferdams, caissons, etc. The illustration shows a Hayward Orange Peel Bucket dredging inside of a pivot pier casing in the construction of a draw bridge.

WRITE FOR CATALOGUE

THE HAYWARD COMPANY *Builders of Digging Machinery*

50 Church Street, New York, U. S. A.

Timber Bridges and Trestles MADE SAFE

against fire dropped by locomotives and their life prolonged by one coat of

CLAPP'S FIRE Resisting Paint

An Inexpensive Money, Life and Property Saver

You need such protection.
We have the goods. We will "show you."
You pay nothing down.

The Clapp Fire Resisting Paint Co.
BRIDGEPORT, CONN.

28 Years of Continuous Service

have demonstrated the lasting qualities of

CORTRIGHT
METAL SHINGLES

THESE Metal Shingle Roofs put on 28 years ago are in good condition today and have never needed repairs.

Cortright Shingles are moderate in price; are rain and storm-proof; wind tight; fire-resisting and add greatly to the appearance of any structure.

Just the covering for Railroad Buildings.

Our catalog "Concerning That Roof," together with prices, sent promptly on request.

Cortright Metal Roofing Co.
Philadelphia *and* **Chicago**

KELLY-DERBY CO., Inc.
349 Peoples Gas Building
Chicago, Ill.

Headquarters for

Pumps
Power Heads

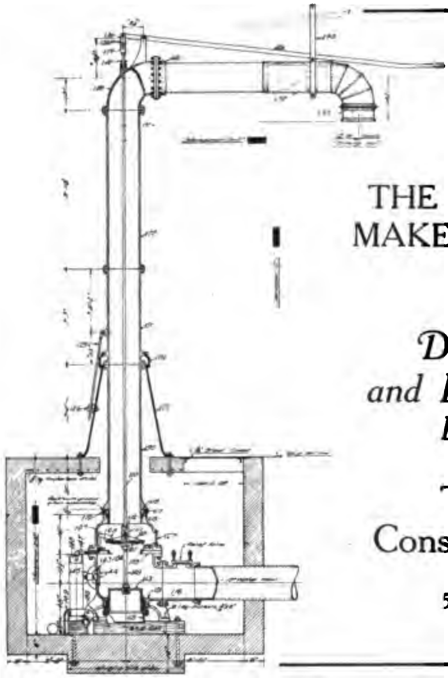
RAILWAY SUPPLIES KCD PEOPLES GAS BLDG. CHICAGO

Engines
Motors

Well Cylinders
Well Strainers

Steel Trucks
Generators

Feed Water Heaters and Purifiers, Hose, Belting
Packing, Diaphragms, Pump Valves
Dredging Sleeves, Cushions



MOST MODERN
WATER COLUMN
Ever Built

THE BALANCED VALVE
MAKES WATER HAMMER
IMPOSSIBLE

*Dawson Standpipe
and Balanced Valve Co.
Bluefield, W. Va.*

T. W. SNOW
Construction Company
Western Manufacturers
537 So. Dearborn Street
CHICAGO

Eight Out of Ten Railroads
Entering New York
and Many Others Use

HUDSON
ASPHALT
ROOFING
PRODUCTS
TRADE MARK

viz.

Protection Brand Roofing. Mineral surfaced. Has 6 inch lap (Pat. Nov. 18-02). Laid with all nails covered. Joints absolutely tight. A permanent Roofing which can be quickly applied.

Hudson Asphalt Shingles. Slate surfaced (Red or Green). Artistic, Durable, Economical. The ideal roofing for stations.

Rockland Roofing. Mineral surfaced. Red, Green and Gray.

Arrow Brand Roofing. Sand or Gravel surfaced.

Hudson Brand Asphalt Felts. For sheathing buildings. For reinforcing Slate and Tile Roofs. Odorless—excellent for sheathing ice-houses.

Samples and new book "Shingling and Roofing" sent on request

Asphalt Ready Roofing Co.
9 CHURCH STREET
NEW YORK

Full Cycle Automatic

COALING STATIONS

Built in all sizes and capacities

Operates successfully under adverse as well as favorable conditions. Serves any number of tracks

WRITE FOR DETAILS

Chicago Office
933 Monadnock

WILLIAMS, WHITE & CO.
MOLINE, ILL., U. S. A.

Pittsburgh Office
808 House Bldg.

Railway Age Gazette

℄ A weekly journal devoted exclusively to the interests of railway men, covering completely all branches of railway work.

℄ Every issue of the Railway Age Gazette contains articles on engineering subjects, and the third regular issue of each month, is a " Maintenance of Way Number," containing a 24-page section devoted exclusively to maintenance of way subjects.

℄ During the annual meeting of the American Railway Engineering Association the Railway Age Gazette publishes the " Maintenance of Way Daily," in which the proceedings of the association are published verbatim.

℄ The subscription price of the Railway Age Gazette, including the Maintenance of Way Number each month and dailies, is $5.00 a year.

℄ We make a special subscription price of $1.00 a year for the Maintenance of Way Number (third issue of each month) and the Maintenance of Way Dailies, 16 issues.

Send subscriptions to
SIMMONS-BOARDMAN PUBLISHING CO.
NEW YORK CHICAGO CLEVELAND

REVERE RUBBER CO.

Manufacturers of High Grade
Mechanical Rubber Goods

Made to one specification —*SERVICE*

REVERE

BRANCHES:

Boston, Mass.
New York, N. Y.
Philadelphia, Pa.
Pittsburgh, Pa.

CHICAGO,
ILL.

Kansas City, Mo.
Minneapolis, Minn.
New Orleans, La.
San Francisco, Cal.

FACTORIES:
Chelsea, Mass., and Providence, R. I.

GREAT LAKES DREDGE & DOCK COMPANY

RIVER AND HARBOR IMPROVEMENTS
FOUNDATIONS, BRIDGES, PIERS
BREAKWATERS, LIGHTHOUSES, TUNNELS
PNEUMATIC AND SUB-MARINE WORK

CHICAGO, ILL.
MONROE BUILDING
MILWAUKEE, WIS.
491-509 CANAL ST
DULUTH, MINN.
ALWORTH BUILDING
SAULT STE MARIE, MICH
ADAMS BUILDING
AMHERSTBURG
ONT CANADA

CLEVELAND, OHIO
WILLIAMSON BUILDING
BUFFALO, N.Y
D.S MORGAN BUILDING
ALBANY, N.Y
27 LUMBER DISTRICT
BOSTON, MASS.
OLIVER BUILDING

Use **DICKINSON**

CAST IRON CHIMNEYS

Durable, Cheap and Fireproof

Paul Dickinson, Inc. 3346 SO. ARTESIAN AVE. CHICAGO

REMEMBER--We Make Smoke Jacks, Ventilators and Cast Iron Buildings Also

PLACING CONCRETE THE "PNEU" WAY

Saves half the cost -- No obstruction to traffic -- Safety First

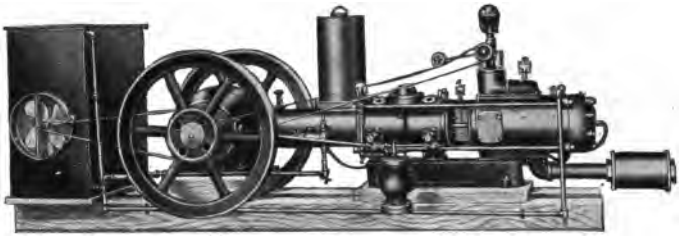
CONCRETE MIXING & PLACING CO

The Compressed Air Method

123 W. Madison St. CHICAGO

"*Chicago Pneumatic*" Air Compressor

GASOLINE or FUEL OIL DRIVEN



Is especially adapted for work on bridges and buildings where portable outfit is necessary.

High Speed, Self Oiling, Self Contained, Direct Connected

Manufactured By

CHICAGO PNEUMATIC TOOL CO.

1010 Fisher Bldg.
Chicago

52 Vanderbilt Ave.
New York

JAMES O. HEYWORTH

General Contractor

Harvester Building

CHICAGO

RAILROAD WORK
RIVER AND HARBOR WORK
HYDRO-ELECTRIC DEVELOPMENT
HEAVY EXCAVATION
CONCRETE CONSTRUCTION

ESTIMATES FURNISHED

OGLE *AUTOMATIC*
LOCOMOTIVE FUEL STATIONS

Are a Necessity in Economical
Fuel Handling for Locomotives

¶ They are automatic in operation, saving labor costs.

¶ They are simple and rigid in construction, saving maintenance cost.

¶ Their reliability and efficiency save on operating costs.

¶ Send us your inquiries for coaling stations.

¶ We will be pleased to furnish plans and a proposition for steel, timber or concrete construction.

Ogle Construction Co.
332 S. Michigan Ave., CHICAGO

ALWAYS ON THE JOB

AND MAKE GOOD

Barker Mail Crane

"SELF ADJUSTING" COIL SPRINGS, HOLD THE POUCH

It is assembled, painted two coats, and ready to set up. Set up in two hours new, or changed in 30 minutes

Practically indestructible, the standard crane of a large number of leading roads. We are selling hundreds of them

PRICE $13.00, $5.00 cheaper than you can build and erect wooden cranes

Send For
LATEST CATALOGUE

BARKER MAIL CRANE CO.
CLINTON, IOWA

BRIDGE, STATION and
TANK

PAINTS

For forty years we have made a specialty of the above paints, and have furnished more bridge paints to the railroads than all others combined.

CHEESMAN & ELLIOT *Owners*

Office: 100 William St.
NEW YORK CITY

NATIONAL PAINT WORKS
WILLIAMSPORT, PA.
BROOKLYN, N. Y.

NICHOLS

Turntable Tractors
Transfer Tables
Bridge Machinery

Geo. P. Nichols & Bro.
Old Colony Building :: CHICAGO

STROBEL STEEL CONSTRUCTION CO.
1744 Monadnock Block
CHICAGO, ILL.

CONTRACTING ENGINEERS

STRUCTURAL STEEL WORK

BRIDGES TURNTABLES BASCULE BRIDGES

National Blue Print Company
(A. E. Lichty, Manager)

BLUE PRINTS, BLUE LINE PRINTS
BLACK LINE PRINTS, PHOTO PRINTS
NEGATIVES, MAP MOUNTING, DRAWINGS

Drawing Materials. Tracings Reproduced
360-61 Monadnock Block, CHICAGO

COLUMBIAN MAIL CRANE CO., *Manufacturers of*

The Columbian Steel Mail Crane

which is the best in the world. In use on 200 railroads in the United States, Canada and Cuba. We also manufacture Steel Cattle Guards and Mail Catchers.

We wish to call your special attention to our Steel Cattle Guard, which is absolutely the best and strongest guard in the world, at a reasonable cost. Eight foot guards $8.00 per set.

Over one-half of all the Mail Cranes in use on the American Continent are of our manufacture. Write for catalogue and prices.

COLUMBIAN MAIL CRANE CO., Columbus, O., U. S. A.

ESTABLISHED 1893

MISSOURI VALLEY BRIDGE & IRON CO.

LEAVENWORTH, KAN.

Engineers and Builders of Bridges

Concrete or Masonry Piers
Pneumatic or Open
Foundations, Steel Spans
Viaducts, Buildings, etc.
Concrete Bins & Elevators

***The* Leading Publication In Your Field**

The most widely quoted technical journal in the world devoted to a Thorough, Authoritative and Unbiased Recording of Current Engineering Progress and Practice—Such is

ENGINEERING NEWS

Published weekly in the interests of Civil, Structural, and Consulting Engineers, Railway and Public Service Engineers, Contracting Engineers, and Manufacturers of Engineering and Contracting Equipment and Supplies.

Subscription $5.00 per annum

Engineering News

HILL BUILDING
10th Ave. and 36th St.
NEW YORK CITY

Granite Roofing

1885 ⟵⟶ 1915

Camden Passenger Terminal, Pennsylvania Railroad, covered with Granite Roofing —160,000 square feet

The Pennsylvania Railroad System

alone has upwards of 1,500,000 square feet of Granite Roofing in service.

That system commenced to use Granite Roofing 18 years ago. It selected Granite Roofing for the largest building of its kind roofed this year—see illustration.

Granite Roofing enjoys similar popularity with the other large railroads on this continent.

WARREN CHEMICAL & MANUFACTURING CO.

Dept. Barrett Manufacturing Co.

19 Battery Place, New York

Successor to

EASTERN GRANITE ROOFING CO.